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1922/23

UNIVERSITY OF
PENNSYLVANIA
BULLETIN

TOWNE SCIENTIFIC
SCHOOL

(Founded 1875)

ANNOUNCEMENT

1922-1923



Founded 1740

Philadelphia, Pa., December 3, 1921; Volume XXII,
No. 10. Published Weekly by the University.
Entered at the Philadelphia, Pa., Post Office as
second class matter. Acceptance for mailing at the
special rate of postage provided in Section 1103.
Act of October 3, 1917, Authorized July 29, 1918.

CATALOGUE AND ANNOUNCEMENTS OF THE UNIVERSITY

Copies of the University Catalogue may be obtained upon application to the Secretary of the University, 3446 Walnut Street, Philadelphia.

The Announcements of the several Schools of the University, *containing more detailed information as to courses than is given in the University Catalogue*, may be had by application to the Deans or Directors *University Catalogue*, may be had by application to the Deans or Directors of those schools. The list of these Announcements follows:

THE COLLEGE (including Arts and Science and Biology). *Apply to the Dean, College Hall.*

THE COLLEGE COURSES FOR TEACHERS. *Apply to the Director, College Hall.*

THE SUMMER SCHOOL. *Apply to the Director, College Hall.*

THE TOWNE SCIENTIFIC SCHOOL (including courses in Chemistry, Chemical Engineering, Mechanical, Electrical and Civil Engineering). *Apply to the Dean, Engineering Building.*

THE WHARTON SCHOOL OF FINANCE AND COMMERCE. *Apply to the Dean, Logan Hall.*

THE SCHOOL OF EDUCATION. *Apply to the Dean, College Hall.*

THE SCHOOL OF FINE ARTS (including Architecture, Music, and Fine Arts). *Apply to the Dean, Harrison Hall.*

THE GRADUATE SCHOOL. *Apply to the Dean, College Hall.*

THE GRADUATE SCHOOL OF BUSINESS ADMINISTRATION. *Apply to the Dean of the Graduate School, College Hall.*

THE SCHOOL OF MEDICINE. *Apply to the Dean, Medical Laboratories Building.*

THE SCHOOL OF LAW. *Apply to the Dean, Law School Building.*

THE SCHOOL OF DENTISTRY AND COURSES FOR DENTAL HYGIENISTS. *Apply to the Dean, Evans Institute Building.*

THE SCHOOL OF VETERINARY MEDICINE. *Apply to the Dean, Veterinary Building.*

THE OFFICE OF ADMISSIONS (Undergraduate Courses). *Apply to the Director, in Harrison Hall.*

THE GRADUATE SCHOOL OF MEDICINE. *Apply to the Dean, Medical Laboratories Building.*

THE SCHOOL OF HYGIENE AND PUBLIC HEALTH. *Apply to the Director, Hygiene Laboratory.*

THE EVENING SCHOOL OF ACCOUNTS AND FINANCE. *Apply to the Director, Logan Hall.*

EXTENSION COURSES. *Apply to the Director, Logan Hall.*

UNIVERSITY OF
PENNSYLVANIA

TOWNE SCIENTIFIC SCHOOL

(Founded 1875)

ANNOUNCEMENT
1922 - 1923



Founded 1740

PHILADELPHIA
PRESS OF THE UNIVERSITY OF PENNSYLVANIA

1922

1922

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THE UNIVERSITY

LOCATION

The buildings of the University of Pennsylvania are situated in Philadelphia, on property covering an area of one hundred and ten acres. The University may be reached from the various railroad stations as follows: From the West Philadelphia station of the Pennsylvania Railroad, on foot west on Woodland Avenue, a walk of less than ten minutes; from the Philadelphia and Reading Terminal station by the subway, Thirteenth and Market Streets, west to Thirty-fourth Street, by Darby, Angora or Chester cars; or from the Baltimore and Ohio Railroad station by a walk of one square south to Walnut Street, thence by car over the bridge west to Thirty-fourth Street.

All letters of inquiry regarding the internal regulations and requirements of the Towne Scientific School should be addressed to the Dean, and *not* to the Secretary of the University.

ACCOMMODATIONS FOR STUDENTS

Lodging for students to the number of nearly one thousand is provided in the present dormitory system, which comprises an extended group of contiguous houses fronting upon three open courts. Plans of the dormitories, prices and other details may be obtained upon application to the Bursar of the University, College Hall.

Board and lodging may be obtained also in the immediate vicinity of the University. Upon application at the office of the Dean, lists of approved boarding houses may be seen.

HOUSTON HALL

Houston Hall is the home of the Houston Club, to membership in which any member of the University is eligible. A fee of twenty dollars (\$20.00) is added to the tuition fee of every student in the Towne Scientific School for the privileges of the Gymnasium, the Houston Club and Athletic Association.

The Club is the exponent of the social side of Pennsylvania life. Its purposes are to provide for the students a place where all may meet socially on common ground, and to furnish every available

facility for healthy recreation and amusement in leisure hours. The equipment of the Hall includes a library and reading room, with a large number of periodicals and newspapers; smoking rooms, billiard and pool tables, tables for chess and checkers; a correspondence room; bowling alleys, shuffle boards; athletic trophy rooms; a large auditorium with grand organ; rooms for the University papers and other organizations; a post-office "sub-station," barber shop, book and general supply store; a luncheon buffet and dining room; a dark room for amateur photographers and many other rooms for general purposes.

The Christian Association, which has its headquarters in Houston Hall, is prepared to furnish prospective students, through its Secretary, full information with regard to the various undergraduate social activities, both secular and religious.

ACTING PROVOST

JOSIAH HARMAR PENNIMAN, PH.D., LL.D.

CORPORATION

THE TRUSTEES OF THE UNIVERSITY OF PENNSYLVANIA

THE GOVERNOR OF PENNSYLVANIA: President
ex-officio.

ELECTED

- 1876. CHARLES CUSTIS HARRISON, LL.D.
- 1896. RANDAL MORGAN, A.M.
- 1898. SAMUEL FREDERIC HOUSTON, PH.B.
- 1903. ROBERT GRIER LE CONTE, M.D.
- 1903. JOSHUA BERTRAM LIPPINCOTT, A.B.
- 1905. ARTHUR LATHAM CHURCH, B.S.
- 1906. GEORGE HARRISON FRAZIER, A.B.
- 1910. JOHN CADWALADER, LL.D.
- 1910. CHARLES LOUIS BORIE, JR., B.S.
- 1910. LOUIS CHILDS MADEIRA, B.S.
- 1911. EDWARD TOWNSEND STOTESBURY.
- 1911. GEORGE WHARTON PEPPER, D.C.L., LL.D.
- 1911. MORRIS LEWIS CLOTHIER, LL.D.
- 1911. Hon. JOHN CROMWELL BELL, LL.D.
- 1911. RICHARD ALEX. FULLERTON PENROSE, JR., PH.D.
- 1916. WILLIAM AUGUSTUS REDDING, LL.B.
- 1917. DAVID MILNE, PH.B., A.M.
- 1919. JOHN MARSHALL GEST, A.M., LL.B.
- 1919. JOSEPH E. WIDENER.
- 1921. CHARLES DAY, M.E.
- 1921. CHARLES J. HATFIELD, A.M., M.D.
- 1921. THOMAS S. GATES, PH.B., LL.B.

SECRETARY OF THE CORPORATION
EDWARD W. MUMFORD, PH.B.

CALENDAR FOR 1922-23

1922

- Sept. 9, Saturday....Last day to register for September entrance examinations without paying the extra fee.
- Sept. 14, Thursday....Last day for filing applications for admission to the first term without paying the late application fee.
- Sept. 18 to Sept. 27...Entrance examinations. Monday, 9 A. M., to Wednesday, 5 P. M.
- Sept. 18 to Sept. 23...Re-examination of Conditioned Students. Monday, 9 A. M., to Saturday, 6 P. M.
- Sept. 26-27-28.....Registration and Advising of students.
- Sept. 29, Friday.....Session begins, 10 A. M.
- Nov. 29, Wednesday..Thanksgiving Recess begins, 6 P. M.
- Dec. 4, Monday.....Thanksgiving Recess ends, 8.30 A. M.
- Dec. 22, Friday.....Christmas Recess begins, 6 P. M.

1923

- Jan. 3, Wednesday..Christmas Recess ends, 8.30 P. M.
- Jan. 20, Saturday....Last day to register for January-February Entrance Examinations without paying the extra fee.
- Jan. 27, Saturday....Last day for filing applications for admission to the second term without paying the late application fee.
- Jan. 29 to Feb. 7.....Entrance Examinations. Monday, 9 A. M., to Wednesday, 6 P. M.
- Jan. 29, Monday.....Mid-Year Examinations, 9 A. M.
- Feb. 5, Monday.....Re-examination of students conditioned in second-term courses.
- Feb. 12, Monday.....Second term begins, 8.30 A. M.
- Feb. 14, Wednesday..Mid-Year Convocation of University Council for the Conferring of Degrees in Course.

- Feb. 22, Thursday . . . University Day. Recess in all Departments.
- Mar. 28, Wednesday . . . Easter Recess begins, 6 P. M.
- Apr. 5, Thursday . . . Easter Recess ends, 8.30 A. M.
- Apr. 30, Monday Last day for receipt of Theses, Prize Essays and Reports.
- June 4, Monday Final Examinations, 9 A. M.
- June 17, Sunday Graduation Sermon.
- June 20, Wednesday . . Commencement Convocation of University Council for the Conferring of Degrees in Course.
- June 18 to 23 Entrance Examinations. Monday, 9 A. M., to Saturday, 6 P. M.
- Sept. 8, Saturday . . . Last day to register for September Entrance Examinations without paying the extra fee.
- Sept. 13, Thursday . . . Last day for filing applications for admission to the first term without paying the late application fee.
- Sept. 17 to 26 Entrance Examinations. Monday, 9 A. M., to Wednesday, 6 P. M.
- Sept. 17 to 22 Re-examination of Conditioned Students. Monday, 9 A. M., to Saturday, 6 P. M.
- Sept. 25-26-27 Registration and Advising of Students.
- Sept. 28, Friday Session begins, 10 A. M.

ADMINISTRATIVE OFFICERS

Acting Provost—JOSIAH H. PENNIMAN, PH.D., LL.D.
Office, 104 College Hall.

Bursar—JOSEPH J. SUTTON, B.S. in Econ.
Office, 3433 Woodland Avenue.

Director of Office of Admissions—GEORGE W. MCCLELLAND, PH.D.
Office, Alfred C. Harrison Hall.

OF THE TOWNE SCIENTIFIC SCHOOL

Dean of the Towne Scientific School Faculty—JOHN FRAZER, PH.D.
Office, Engineering Building. Office hours, 9 A. M. to 12 M. daily.

OF THE DEPARTMENT OF PHYSICAL EDUCATION

Students' Physicians—The Trustees have appointed DRs. JOHN H. MUSSER, JR., ALEXANDER RANDALL, L. J. A. SMITH, A. W. PHILLIPS, JOHN ARNETT, and J. HOWARD SMITH to act as students' physicians. A Students' Dispensary is conducted daily at the University Hospital.

Ophthalmologist—HUNTER SCARLETT, M.D.

Oto-Laryngologist—PHILIP S. STOUT, M.D.

THE TOWNE SCIENTIFIC SCHOOL

FACULTY

JOSIAH H. PENNIMAN, PH.D., LL.D., ACTING PROVOST, and Professor of English Literature.

_____, Vice-Provost.

JOHN FRAZER, PH.D., Dean of the Towne Scientific School, and Professor of Chemistry.

PROFESSORS

EDGAR F. SMITH, PH.D., CHEM.D., SC.D., L.H.D., LITT.D., LL.D., Emeritus Professor of Chemistry.

FELIX E. SCHELLING, A.M., PH.D., LITT.D., LL.D., JOHN WELSH Centennial Professor of History and English Literature.

HUGO ALBERT RENNERT, PH.D., LL.D., Professor of Romanic Languages and Literature.

EDWIN S. CRAWLEY, PH.D., THOMAS A. SCOTT Professor of Mathematics.

ARTHUR W. GOODSPEED, PH.D., Professor of Physics, and Director of the Randal Morgan Laboratory of Physics.

CLARENCE G. CHILD, A.M., PH.D., L.H.D., LL.D., Professor of English Literature.

ALEXANDER C. ABBOTT, M.D., DR.P.H., SC.D., Professor of Hygiene and Bacteriology.

*ISAAC J. SCHWATT, PH.D., Professor of Mathematics.

DANIEL B. SHUMWAY, PH.D., Professor of German Philology.

ARTHUR H. QUINN, PH.D., Professor of English and Dean of the College Faculty.

J. VERNE STANFORD, B.S., M.E., Professor of Mechanical Engineering.

GEORGE H. HALLETT, A.M., PH.D., Professor of Mathematics.

CORNELIUS WEYGANDT, PH.D., Professor of English Literature.

HORACE C. RICHARDS, A.B., PH.D., Professor of Physics.

EDGAR A. SINGER, JR., PH.D., Professor of Philosophy.

HENRY BROWN EVANS, PH.D., Professor of Mathematics.

* Absent on leave.

- R. TAIT MCKENZIE, A.M., M.P.E., M.D., Professor of Physical Education, Director of the Department of Physical Education.
- OWEN L. SHINN, Ph.D., Professor of Applied Chemistry.
- WALTER T. TAGGART, Ph.D., BLANCHARD Professor of Chemistry, and Director of the Department of Chemistry.
- J. P. WICKERSHAM CRAWFORD, Ph.D., Professor of Romanic Languages and Literatures.
- OLIVER E. GLENN, A.M., Ph.D., Professor of Mathematics.
- HAROLD C. BARKER, A.M., Ph.D., Professor of Physics.
- FREDERICK H. SAFFORD, A.M., Ph.D., Professor of Mathematics.
- JOHN J. MORRIS, Professor of Mechanical Constructive Practice.
- EDWARD L. INGRAM, C.E., Professor of Railroad Engineering and Geodesy.
- HERMAN C. BERRY, A.B., B.S. IN C.E., Professor of Materials of Construction.
- WILLIAM S. PARDOE, B.A.Sc., Professor of Hydraulic Engineering.
- ROBERT H. FERNALD, M.E., A.M., Ph.D., WHITNEY Professor of Dynamical Engineering, and Director of the Department of Mechanical Engineering.
- HAROLD PENDER, Ph.D., Professor of Electrical Engineering, and Director of the Department of Electrical Engineering.
- C. E. CLEWELL, E.E., Professor of Electrical Engineering.
- ERNEST M. PATTERSON, A.M., Ph.D., Professor of Economics.
- WILLIAM H. KAVANAUGH, M.E., Professor of Experimental Engineering.
- MILO S. KETCHUM, C.E., Professor of Civil Engineering, and Director of the Department of Civil Engineering.
- SHELDON W. ANDING, Lieut. Col., U.S.A., Professor of Military Science and Tactics.
- GEORGE G. CHAMBERS, Ph.D., Professor of Mathematics.
- HOWARD H. MITCHELL, Ph.B., Ph.D., Professor of Mathematics.
- THOMAS P. McCUTCHEON, Ph.D., Professor of Chemistry.
- JOHN FRAZER, Ph.D., Professor of Chemistry, and DEAN OF THE TOWNE SCIENTIFIC SCHOOL.
- HIRAM S. LUKENS, Ph.D., Professor of Chemistry.

ASSISTANT PROFESSORS

- DAVID H. BERGEY, A.M., M.D., Assistant Professor of Bacteriology.
- FREDERICK EHRENFELD, Ph.D., Assistant Professor of Geology and Mineralogy.

- HORACE P. FRY, B.S. IN E.E., Assistant Professor of Mechanical Drawing.
- WILLIAM C. H. SLAGLE, C.E., Sc.D., Assistant Professor of Descriptive Geometry and Drawing.
- MAURICE J. BABB, Ph.D., Assistant Professor of Mathematics.
- THOMAS D. O'BOLGER, A.M., Ph.D., Assistant Professor of English.
- THOMAS D. COPE, A.B., Ph.D., Assistant Professor of Physics.
- EDWARD T. GRANDLIENARD, C.E., Assistant Professor of Civil Engineering.
- PERCY V. D. SHELLY, A.M., Ph.D., Assistant Professor of English.
- MELVIN R. HARKINS, A.B., Ph.D., Assistant Professor of Physics.
- DICRAN H. KABAKJIAN, A.B., M.S., Ph.D., Assistant Professor of Physics.
- DANIEL E. OWEN, A.M., Ph.D., Assistant Professor of English.
- GEORGE W. McCLELLAND, A.M., Ph.D., Assistant Professor of English.
- JOHN C. MENDENHALL, A.M., Assistant Professor in English.
- STANLEY P. SHUGERT, Ph.D., Assistant Professor of Mathematics.
- GEORGE E. CROFOOT, B.S. IN M.E., Assistant Professor of Mechanical Engineering.
- HERBERT S. HARNED, Ph.D., Assistant Professor of Chemistry.
- CLARENCE L. ECKEL, B.S. IN C.E., Assistant Professor of Civil Engineering.
- JOHN H. MÜLLER, M.S., Ph.D., Assistant Professor of Chemistry.
- MIGUEL ROMERA-NAVARRO, A.B., L. IN D., Assistant Professor of Spanish.
- CHARLES D. FAWCETT, B.S. IN E.E., Assistant Professor of Electrical Engineering.
- DANIEL L. WALLACE, Dr. IN CHEM., Assistant Professor of Chemistry.
- WILLIAM I. BOOK, B.S., Ph.D., Assistant Professor of Physics.
- RALPH W. DUNCAN, Ph.D., Assistant Professor of Physics.
- CHARLES BLIZARD BAZZONI, B.S., Ph.D., Assistant Professor of Physics.
- JOHN ROBERT KLINE, A.B., A.M., Ph.D., Assistant Professor of Mathematics.
- WILLIAM P. HARBESON, B.S., LL.B., Assistant Professor in English.
- JOHN DOLMAN, JR., B.S., A.M., Assistant Professor in English and Forensics.

FRANK A. LAURIE, JR., B.S., A.M., Assistant Professor in English.
PAUL C. KITCHEN, PH.D., Assistant Professor in English.
ALBERT C. BAUGH, A.M., PH.D., Assistant Professor in English.
RICHARD E. BROWN, E.E., M.M.E., Assistant Professor in Electrical Engineering.

INSTRUCTORS

EDWIN M. FOGEL, PH.D., Instructor in German.
JOHN F. MURPHY, Instructor in Foundry Work.
PERCIVAL R. HALL, Instructor in Iron Working.
GEORGE W. H. FAWKES, Instructor in Wood Working.
CHARLES W. BLOEMKER, Instructor in Forging.
WILLIAM T. LEGGO, C.E., Instructor in Civil Engineering.
CLEMENT VOLLMER, A.B., PH.D., Instructor in German.
MATTHEW W. BLACK, A.M., Instructor in English.
PAUL H. MUSSER, A.B., Instructor in English.
WILLIAM A. SLOAN, B.S. IN M.E., Instructor in Mechanical Engineering.
HAROLD S. STINE, A.B., Instructor in English.
KARL W. H. SCHOLZ, A.M., PH.D., Instructor in German.
EMILE MALAKIS, A.B., Instructor in French.
GEORGE F. COLE, A.B., A.M., Instructor in French.
ISAAC C. CORNOG, A.B., Instructor in Physics.
RAYMOND MORGAN, A.B., Instructor in Physics.
HARRY SELTZ, B.S. IN CH.E., Instructor in Chemistry.
JOSEPH M. THOMAS, A.B., Instructor in Mathematics.
MATTHIAS A. SHAABER, A.B., Instructor in English.
JOSEPH A. MEREDITH, A.B., M.A., Instructor in Romanic Languages.
RICHARD A. ARMS, PH.D., Instructor in Mathematics.
JOHN L. CAMPION, PH.D., Instructor in German.
ROBERT E. KEIGHTON, A.B., Instructor in English.
BRUCE W. McCULLOUGH, PH.D., Instructor in English.
EDWARD B. WILLIAMS, A.M., Instructor in Romanic Languages.
DOMENICO VITTORINI, A.M., LITT.D., Instructor in Romanic Languages.
JOEL C. SCHUGAR, A.B., Instructor in German.
AXEL J. UPPVALL, PH.D., Instructor in French.
HERMAN WEIGAND, PH.D., Instructor in German.

- A. FRANCIS ALLWEIN, B.S. IN E.E., Instructor in Mechanical Engineering.
- WALTER J. SEELEY, B.S. IN E.E., Instructor in Electrical Engineering.
- FRANK BINNS, B.S., Instructor in Mechanical Engineering.
- FRANK D. CARVIN, B.S. IN M.E., Instructor in Mechanical Engineering.
- KINGSLEY E. DEROSAY, B.S. IN CH.E., Instructor in Mechanical Engineering.
- CONRAD V. HAHN, B.S. IN M.E., Instructor in Mechanical Engineering.
- JOHN C. RHODES, B.S. IN CH.E., Instructor in Chemistry.
- J. WARREN MILLER, PH.D., Instructor in Mathematics.
- EDWARD S. BRADLEY, A.B., Instructor in English.
- MORRISON C. BOYD, A.M., Instructor in English.
- HARRY A. ALSENTZER, B.S., Instructor in Chemistry.
- HORACE R. BLANK, B.S. IN CH., Instructor in Chemistry.
- GEOFFREY JAMES, B.S., Instructor in Chemistry.
- CHARLES C. BUTTERWORTH, 2D, A.B., Instructor in English.
- WILLIAM R. CRAWFORD, A.B., Instructor in English.
- CHARLES E. CUNNINGHAM, A.B., Instructor in English.
- REESE D. JAMES, A.M., Instructor in English.
- EDWIN F. PIKE, B.S. IN CH.E., Instructor in Chemistry.
- EMORY F. STOVER, B.S. IN C.E., Instructor in Civil Engineering.
- WILLIAM HENRY BARTON, JR., B.S. IN C.E., Instructor in Civil Engineering.
- CHARLES N. WEYL, B.S., in Electrical Engineering.
- ARSENE N. LUCIAN, A.B., PH.B., PH.D., Instructor in Physics.
- HENRY K. SANGREE, A.B., M.D., Instructor in Physics.
- LEON E. SMITH, B.S., Instructor in Physics.
- RUSSELL PAUL SMITH, A.S., Instructor in Physics.
- THEODORE A. SMITS, B.S., Instructor in Physics.
- FRANKLIN B. WRIGHT, B.S., Instructor in Physics.
- GURLYM E. OWEN, PH.B., Instructor in Physics.
- WALLACE M. McNABB, M.S., Instructor in Chemistry.
- AUGUST ULMANN, JR., M.E., Instructor in Mechanical Engineering.
- LOUIS H. DOANE, B.S. IN C.E., Instructor in Civil Engineering.
- EDWARD P. FENIMORE, Instructor in Chemistry.
- ARTHUR K. GRAHAM, B.S. IN CH., Instructor in Chemistry.
- ERNEST H. DICKENSON, A.B., E.M., Instructor in Mechanical Engineering.
- EDWARD C. LUKENS, A.B., Instructor in Business Law.

ASSISTANTS

MARTIN A. BRUMBAUGH, A.B., Instructor in Mathematics.
WILLIAM CLEVER, Assistant in Civil Engineering.
CARLOS BERGUIDO, A.B., Assistant in Romanic Languages.
WILLIAM T. HELLINGS, A.B., Assistant in Mathematics.
JOHN M. STROUP, Ph.B., Assistant in Mathematics.
JOHN E. HAWKINS, Assistant in Chemistry.

ADMISSION

Complete information concerning the requirements for admission is given in the Announcement of Information Concerning Admission. A copy of that bulletin will be sent upon a request addressed to the **Director of Admissions, Fine Arts Building, University of Pennsylvania.**

Women students are not admitted to the Towne Scientific School.

APPLICATIONS FOR ADMISSION

Every candidate for admission should file an application in the Office of Admissions on a blank provided for that purpose. Copies of that blank may be obtained by writing to the Director of Admissions, Fine Arts Building, University of Pennsylvania, Philadelphia, Pa.

The University will be pleased to receive applications from prospective students two, or even three, years before they expect to begin work at the University.

LATE APPLICATION FEE

A fee of five dollars will be charged each applicant whose application, together with the necessary credentials, has not been filed in the Office of Admissions at least two weeks before the opening day of the term during which the applicant desires to begin work at the University. In such cases the fee must be paid before a certificate of admission will be issued, but will not be charged unless the action upon the application is favorable. This fee will not be returned.

If entrance examinations are taken, the necessary credentials for admission to the examinations will be considered as part of the credentials that should be filed before the two weeks' period mentioned in the preceding paragraph.

ENTRANCE REQUIREMENTS

To be admitted as a regular student in the Freshman Class a candidate for admission *must* obtain credit as follows:

1. A total of 15 units in acceptable college preparatory subjects. (See below).

2. Of the 15 units, at least $11\frac{1}{2}$ units must be in subjects in the following list: English, History, Mathematics, Foreign Languages and the Sciences.

3. The 15 units must include the following:

English.....	3	units
History.....	1	unit
A Modern Foreign Language.....	2	units
Algebra.....	$1\frac{1}{2}$	units
Plane Geometry.....	1	unit
Solid Geometry.....	$\frac{1}{2}$	unit
Plane Trigonometry.....	$\frac{1}{2}$	unit
Physics.....	1	unit

The foreign language must be French, German, Spanish, or Italian.

4. Candidates for admission to the *Courses in Chemistry, Chemical Engineering, Civil Engineering, Electrical Engineering and Mechanical Engineering*, who have satisfied the requirements above, with the exception of one or more of the particular subjects mentioned under 3, may, at the discretion of the University, be admitted to take an *irregular* roster including the missing subjects and as much of the regular freshmen work as can consistently be given to them, together with additional college work, if necessary, to meet the minimum requirement as to the amount of work required of Freshmen. The extent of the irregularities in such rosters will depend upon what subjects are missing and their relation to the regular roster. If the irregularities are serious, it may be impossible to complete the requirements for a degree in four years. In all cases the candidate must have a total of 15 units of credit, and not all combinations of deficiencies will be accepted.

SUBJECTS ACCEPTED FOR ADMISSION.

The numbers of units indicate respectively the minimum and maximum number that will be accepted.

English.....	3 to 4	units
History and Civil Government.....	1 to 4	units
Latin.....	2 to 4	units

Greek.....	2 to 3	units
French.....	2 to 4	units
German.....	2 to 4	units
Spanish.....	2 to 3	units
Italian.....	2 to 3	units
Algebra.....	1 to 2½	units
Geometry.....	1 to 1½	units
Trigonometry.....	½	unit
Science, including Physics, Chemistry, Biology, Botany, Zoölogy, Physical Geography and Physiology.		
Miscellaneous Subjects.....	½ to 3½	units

To obtain credit in English, the candidate must have completed the full requirement, as prescribed by the National Conference on Uniform Entrance Requirements in English.

Not more than 3 units of credit in History can be obtained by examination.

Laboratory note-books should not be submitted until called for. They should, however, be ready for submission promptly when requested.

Under the head of Miscellaneous Subjects may be included any subject counted by the candidate's secondary school as a part of the requirement for its diploma, provided the Director of Admissions is satisfied that its subject matter has been properly organized for college preparatory work, and that it has been taught by a competent teacher and with suitable equipment. Typewriting, stenography, military training and physical education are not credited at all, and most miscellaneous subjects, such as drawing and manual training, are not credited for more than one unit each.

No subject will be credited for less than ½ unit.

METHODS OF OBTAINING CREDIT

There are three distinct methods of obtaining the necessary entrance credited as stipulated in the requirements for admission.

1. *By examination.* A candidate for admission may obtain all the necessary entrance credit by passing regular entrance examinations. The examinations may be distributed over a period of two years and four months, but examinations taken more than two years and four months prior to admission will not be counted.

N. B.—This is the only method of admission open to those who have not qualified for the diploma from a standard secondary school.

2. *By school record and certificate.* A candidate who has been graduated sufficiently high in his class from an accredited school may receive credit by school record and certificate for the acceptable subjects included in his course of study. If these subjects do not cover the entire entrance requirements he will be asked to gain the additional units by passing entrance examinations in particular subjects. In order that credit in a subject be granted without examination it should have been taken regularly in class for the full time stipulated in the definition of a Carnegie unit or half-unit.

N. B.—This method of admission will in general be restricted to those who enter the University in the fall following their graduation from school.

3. *By school record and alternative series of examinations.* This method is open to graduates of schools who cannot be certificated; and to those who do not enter college in the year of their graduation.

The candidate is required to supplement his school record by taking either one of the following alternative series of examinations:

1. Comprehensive examinations in four subjects, as defined by the College Entrance Examination Board, one of which must be English, the others to be selected by the applicant. All four examinations must be taken during the same examination series.

The examination in English and two other subjects must be passed, and, in case of failure in a subject, other than English, the average of the grades in the four examinations must be passing or higher.

2. Two special examinations:

(a) An examination in the ability to use the English language as a means of pursuing the various university freshman subjects of study.

(b) A comprehensive examination to test the applicant's mental power, alertness, and general intelligence, but reducing to the lowest possible minimum, the mere memory of the content of the several subjects of study.

Both of these examinations must be taken during the same examination series.

The examination in English must be passed, and the score in the other examination must be high enough to indicate sufficient intelligence and mental power to succeed with university work.

VACCINATION

According to the Regulations of the Bureau of Health of the City of Philadelphia, the University of Pennsylvania is required to refuse

admission to any person except upon a certificate signed by a physician stating that such person has been recently vaccinated or that he or she has previously had smallpox. All persons matriculating in the Town Scientific School will, therefore, have to present such a certificate at the time of matriculation and in default of such certificate must be vaccinated. Official forms furnished by the Bureau of Health of the City of Philadelphia can be obtained by applying in person or by messenger at Room 712, City Hall, between the hours of 9 A. M. and 4 P. M., and on Saturdays from 9 A. M. to 12 M., or at the office of the Dean, Engineering Building.

ADMISSION OF RECENT STUDENTS OF HIGHER INSTITUTIONS

An applicant for admission as a regular student, who has recently been a student in an educational institution ranking higher than a secondary school, should file a formal application for admission as required on page 16, and should present complete credentials concerning his work in all educational institutions above the grammar school. This information should be in the form of official statements from his former institutions, and should be accompanied by a letter of honorable dismissal from the last institution attended.

Blanks for the submission of such records and also a blank for the candidate's formal application may be obtained from the Director of Admissions, in Alfred C. Harrison Hall, University of Pennsylvania, Philadelphia, Pa.

An attempt will be made in each case to determine a point of time in the candidate's previous work at which he had fully completed the requirements for admission to the Freshman class. Work done after that time will be considered for advanced credit, in so far as it corresponds to the requirements for the degree desired by the candidate.

A student who has done sufficient work elsewhere to enable him to complete in one year the work required for the Bachelor's degree, in the course which he proposes to enter, may be admitted to the Senior Class, but no student so admitted will be given a degree until at least twelve units (year hours) of work have been satisfactorily completed at the University.

No student may be admitted as a candidate for a degree after the beginning of the Senior year of the class with which he would graduate.

ENTRANCE EXAMINATIONS

The University gives two series of entrance examinations each year, in January and September. For full information see the bulletin concerning admission.

The University does not give the regular entrance examinations in June. Candidates desiring examinations at that time should take the examinations given by the College Entrance Examination Board. For information concerning the examinations of the Board write to 431 West 117th Street, New York City.

CLASSIFYING EXAMINATIONS

Entering students are strongly advised to review those secondary school subjects which they will continue in the University.

Examinations are given in certain subjects which were begun in the secondary school and are to be continued in the University. These examinations are for the purpose of determining what particular work in these subjects the student should take first. Information concerning one of these examinations is given below. Information concerning the others will be announced after regular class work has begun.

MATHEMATICS M.—This is a classifying examination in Mathematics required of all students entering the engineering courses in the Towne Scientific School, except those who have passed examinations in Mathematics A and F within the year preceding their matriculation and except those who may be given advanced credit in freshman Mathematics (Mathematics 54 and 55). This examination consists of two parts, elementary algebra (Mathematics MA) and elementary plane trigonometry (Mathematics MT), and is a test of the student's ability to use the processes of these subjects. Students who have passed Mathematics A within the year are not required to take Mathematics MA, and those who have passed Mathematics F within the year are not required to take Mathematics MT.

Students who fail to pass Mathematics MA will be required to take Mathematics 53 (Intermediate Algebra) in the first term of Freshman year and to postpone the regular freshman work in College Algebra (Mathematics 55) until the second term. Those who fail to pass Mathematics MT will be required to take Mathematics 52 (Elementary Trigonometry) in the first term of Freshman year and to postpone Mathematics 54 (Higher Trigonometry) until the second term. Students who are thus obliged to postpone beginning the regular work of

Freshman year in Mathematics until the second term will be behind the regular schedule of their class in Mathematics in succeeding terms unless by extra work in the Summer School, or otherwise, they make up the deficiency.

This examination can not be taken until the entrance requirements have been fully satisfied and a certificate of admission issued.

For students entering at the beginning of the year 1921-22 this examination will be given at 10 A. M. on Tuesday, September 26.

Students who do not take this examination on the date announced will be classed, at least temporarily, as if they had taken it and had been placed in the lower group.

GENERAL INFORMATION

STATUS AND CLASSIFICATION OF STUDENTS

A Regular Student is one who has satisfied the Entrance Requirements, and is a candidate for a degree, pursuing his studies in a manner and to the amount prescribed. Regular students only are admitted to the Towne Scientific School.

A unit of work is one hour a week for a year in lecture or recitation, or two hours a week for a year in laboratory, drafting room, field, or shop work.

A student in a course will be advanced to the next higher class if, at the opening of the college year, he has credit in sixty (60) per cent of the total number of units scheduled in the Catalogue as the work of the preceding class.

A student shall have on his roster a number of hours equivalent to not less than ten (10) units, in addition to the required work in Physical Education or Military Training.

FEES AND DEPOSITS

The amounts noted in the appended schedule are for Regular Students, and are for the full academic year. Tuition fees are payable *in advance* in two equal parts; the first on registering for the first term, and the second on February 1. Remittances should be in cash, or by bank draft, certified cheque or postal money order, drawn for the exact amount due, made payable to the University of Pennsylvania, and sent to the Bursar, 3433 Woodland Avenue, Philadelphia, Pa. For detailed "Regulations Governing Payments," see pages 92-94.

Chemistry.....	\$300.00
Chemical Engineering.....	300.00
Civil Engineering.....	300.00
Electrical Engineering.....	300.00
Mechanical Engineering.....	300.00

A matriculation fee of five dollars (\$5.00) is charged for every new student entering the Towne Scientific School.

GENERAL ATHLETIC AND HOUSTON CLUB FEE

A fee of twenty dollars (\$20.00) is added to the tuition of every student in the Towne Scientific School for the privileges of the Gymnasium, the Houston Club, and Athletic Activities. This fee is payable *in advance* in two equal parts on registering in September and February.

ENTRANCE EXAMINATION FEES

A fee of five dollars shall be paid for each series of entrance examinations taken at the University; and an extra fee of five dollars shall be paid if the application for admission to the desired series of examinations is not filed in the Office of Admissions at least one week before the beginning of the series.

LATE APPLICATION FEE

A fee of five dollars shall be paid by each applicant for admission to the Towne Scientific School if his application, together with the necessary credentials, has not been filed in the Office of Admissions at least two weeks before the opening day of the term during which the applicant desires to begin work at the University.

FEE FOR LATE REGISTRATION

Students in all departments, who fail to register, or to complete registration by the satisfaction of all term obligations at the Bursar's Office, within two weeks after the opening day of either term of the University, shall be required to pay an additional fee of five dollars (\$5.00) for late registration.

FEE FOR SPECIAL EXAMINATIONS

If a special examination or re-examination be authorized by the Executive Committee, a fee of five dollars (\$5.00) will be charged.

The student must in each case bring a statement from the Dean showing that he is entitled to such an examination.

DEPOSITS AND EXPENSES

Each student on entering the Towne Scientific School is required to make a money deposit of \$25.00 to cover loss of books, keys, etc., breakage in the laboratories, damage to University property, and other expenses. Any balance is returned upon graduation or withdrawal from College.

GRADUATION AND CERTIFICATE FEES

A graduation fee of twenty dollars (\$20.00) is charged to each candidate for a baccalaureate degree, and a fee of ten dollars (\$10.00) is charged to each candidate for the technical degree of Chemical Engineer, Electrical Engineer, or Mechanical Engineer. *No student will be recommended for a degree or certificate until all fees due the University have been paid.*

DIVISION OF SESSIONS

The college year is divided into two terms of about eighteen weeks each. The first term begins in 1921 on September 30,* at 10 o'clock A. M. The second term begins on February 6, 1922, at 8.30 o'clock, and will end with Commencement on June 14, 1922.

A period of two weeks is set apart for examinations and re-examinations† at the end of the first term, and a period of two weeks for examinations at the end of the second term.

In reporting the standing of each student on the completion of each subject the following grades only are employed:

D Distinguished.

G Good.

P Passed.

N Not passed. (Student is entitled to a re-examination.)

F Failure. (Subject must be repeated in class.)

I Incomplete.

THESES

The theses required of candidates for the technical degrees must be received by the Dean on or before May 1 in each year.

DEGREES

The degree of *Bachelor of Science in Chemistry, Bachelor of Science in Chemical Engineering, Bachelor of Science in Civil Engineering, Bachelor of Science in Electrical Engineering, or Bachelor of Science in Mechanical Engineering* is conferred on students who complete the four-year course in one of these subjects.

The technical degrees of *Chemical Engineer (Ch.E.), Civil Engineer (C.E.), Electrical Engineer (E.E.), and Mechanical Engineer (M.E.)*, are conferred not less than three years after receipt of the baccalaureate degree, upon graduates of the four-year courses in these subjects who have successfully pursued their professions during such period, and who have also presented acceptable original theses.

Similar degrees may be awarded to graduates of other institutions of recognized standing provided the candidate has been in residence at the University of Pennsylvania for not less than one academic year, either as a student or as an instructor.

* Absences are counted from the beginning of the term.

† Re-examinations in second-term subjects only.

SCHOLARSHIPS

Scholarships open to undergraduates in the Towne Scientific School may be divided into two groups: first, those which may be held only by students from certain localities; and, second, those which are general in their allotment. All candidates for scholarships must present themselves for the usual entrance examinations, excepting those who may be admitted on satisfactory diplomas granted by public high or normal schools.

No award of scholarships will be made until after the entrance examinations in June. Only such persons will be eligible for scholarships as have secured full admission in June preceding the opening of the year for which the scholarships are sought. Holders of scholarships who incur conditions forfeit their scholarships.

All candidates for scholarships in the Towne Scientific School (*except those awarded by the City of Philadelphia and the Philadelphia Board of Public Education*) must transmit their applications and credentials to the Provost on or before the 15th day of May preceding the opening of the academic year in which they desire to enter. Scholarship application blanks may be procured from the Chairman of the Scholarship Committee (the Provost).

Special attention is called to the fact that, while possession of a scholarship entitles the holder to free tuition, such holders are bound by all University rules and regulations equally with pay students; and any infraction of these regulations will render a holder liable to the forfeiture of his privileges. A scholarship does not carry with it remission of any fee but that for tuition.

GROUP 1

1. THE PENN SCHOLARSHIPS, two in number, founded in 1816, are filled by the Governor of the State from time to time as vacancies occur. They exist by virtue of a privilege confirmed to the heirs of Thomas Penn, one of the original Proprietaries of the Province of Pennsylvania.

2. THE PHILADELPHIA FREE SCHOLARSHIPS.—Under an agreement with the City of Philadelphia, of date 1882, fifty free scholarships exist in the University for the benefit of graduates from the public schools. Of these, THE BENJAMIN FRANKLIN SCHOLARSHIPS, three in number, were endowed by the late Dr. William Pepper, and THE

SAMUEL V. MERRICK SCHOLARSHIP by the late J. Vaughan Merrick. Candidates are examined by the Board of Public Education, and the scholarships, according to the number becoming vacant at the end of each academic year, are awarded to those who reach the highest grade in examination, provided that such grade be at least sixty-five per cent. *All inquiries concerning these Scholarships should be addressed to the Secretary of the Board of Public Education, City Hall.*

Under another agreement with the City of Philadelphia, made in 1910, seventy-five free scholarships have been established in the University for the benefit of graduates from Philadelphia schools in general. *Inquiries concerning the latter scholarships should be addressed to the Mayor of Philadelphia, City Hall.*

GROUP 2

1. THE BAIRD SCHOLARSHIP, founded in 1889 by Mrs. Matthew Baird provides free tuition for one student.

2. THE MUHR SCHOLARSHIPS, founded in 1895 by the late Simon Muhr, provide free tuition for three students.

3, 4 and 5. THE JAMES LATTA (founded by William J. Latta, Esq.), ROBERT MORRIS and JOHN LOGAN SCHOLARSHIPS, established in 1900, provide free tuition for three students.

6. THE LOUISE HARRISON SCHOLARSHIP, founded in 1900 by Thomas S. Harrison, Esq., provides free tuition for one student in the Department of Chemistry.

7. THE THOMAS S. STEWART SCHOLARSHIP, founded in 1900 by Mrs. Thomas S. Stewart and the Messrs. Thomas S. and Ralph C. Stewart, provides free tuition for one student in Architecture. In the event of no suitable person presenting himself at any time in Architecture, the scholarship may be awarded in other departments.

8. THE HARTMAN KUHN SCHOLARSHIP, founded in 1901 by C. Hartman Kuhn, Esq., in memory of his grandfather, of the Class of 1800, College.

9. THE THOMAS H. POWERS SCHOLARSHIP, founded in 1901 by Mrs. Mary Powers Harris, in memory of her father.

10. THE CHARLES BRINTON COXE SCHOLARSHIP, founded in 1901 by Eckley Brinton Coxé, Jr., Esq., in memory of his father, of the Class of 1862, College.

11. THE E. OTIS KENDALL SCHOLARSHIP, founded in 1901 by the Class of 1879, College, in memory of the late Vice-Provost of the University.

12. THE THOMAS CADWALADER SCHOLARSHIP, founded in 1901 by John Cadwalader, Esq.

13. THE STEPHEN GREENE SCHOLARSHIP, founded in 1901.

14. THE CLASS OF 1878 MEMORIAL SCHOLARSHIP, founded in 1903.

16. THE ALBERT MONROE WILSON SCHOLARSHIP, founded in 1904 by the Alumni of the College, in memory of the late janitor of College Hall, and as a tribute to his zealous fidelity to duty during nearly fifty years of service in the University.

17. THE GEORGE BARNETT SCHOLARSHIP in Mechanical Engineering, founded in 1904 by his daughter, Mrs. Irene Barnett Halstead.

18. THE ECKLEY B. COXE SCHOLARSHIP, founded in 1904 by Mrs. Eckley B. Coxe, in memory of her husband, of the Class of 1858, College.

19. JUSSEFAND FRENCH TRAVELING SCHOLARSHIP, founded 1912, by Joseph G. Rosengarten, Esq., awarded annually upon the recommendation of the Department of French to that student considered best prepared for study at some one of the French universities.

20. THE MARTHA AUSTIN McDOWELL SCHOLARSHIP, founded in 1905 by her father, J. Austin McDowell, Esq., to be awarded without limitation as to department.

21. THE LAVINA BARNETT FAIRCHILD SCHOLARSHIP, founded in 1906 for students in Civil Engineering.

22. THE WILLIAM P. HENSZEY SCHOLARSHIP, founded in 1906 by William P. Henszey, Esq., of Philadelphia, to be awarded without limitation as to department.

23. THE SAMUEL R. SHIPLEY SCHOLARSHIP, founded in 1907.

24. THE ADAM CLARKE THOMPSON SCHOLARSHIP, founded in 1907, by Mrs. Robert E. Cook and Rev. William J. Thompson, in memory of their brother, of the Class of 1892, College.

25. THE S. W. ROBERTS SCHOLARSHIP, founded April, 1882.—About \$50 toward the tuition of one student.

26. THE JOHN WHITE FIELD SCHOLARSHIP, established January, 1899.—For a student from the Central High School.

27. THE FRANCIS PETERS SCHOLARSHIP, established January, 1899.—For a student from the Central High School.

28. THE HOWARD N. POTTS SCHOLARSHIPS, established 1906.—Three free scholarships.

29. THE JOHN CLARKE SIMS MEMORIAL SCHOLARSHIPS, founded in 1909, in memory of the late John C. Sims, a Trustee of the University, and formerly Secretary of the Pennsylvania Railroad. One of the Scholarships is open to persons nominated by the Trustees of the University, and the other is open to employes, and to sons of living or deceased employes of the Pennsylvania Railroad lines, east and west of Pittsburgh, both to be awarded under the rules governing the granting of Scholarships in the University.

30. THE COLEMAN SELLERS SCHOLARSHIP, founded December 7, 1909, by Mrs. S. W. Colton, Jr., in memory of her father, provides for the tuition of a student in Engineering.

31. THE DRIFTON SCHOLARSHIP.—Endowed by Eckley Brinton Cox, Jr., Esq., May 2, 1910, to be used only for young men from the coal regions of Pennsylvania.

32. THE ROBERT HORNER SCHOLARSHIP, founded in 1919 by Samuel Horner, Jr., Esq., in memory of his son, a member of the Class of 1900, College, open to any department.

33 and 34. THE CHARLES E. ELLIS SCHOLARSHIPS, established 1911.—The will of Charles E. Ellis, Esq., provides that the beneficiaries are to be restricted to students of the public schools of Philadelphia, to be appointed by the Superintendent of the public schools through arrangement with the Commonwealth Trust Company. Two scholarships are to be available annually.

35. THE CAMDEN (N. J.) MANUAL TRAINING HIGH SCHOOL SCHOLARSHIP, established in January, 1910, by the Associate Alumni of that school, is awarded annually to a graduate of the same, subject to all the rules and regulations of the University.

36, 37 and 38. WALTER E. HERING SCHOLARSHIPS.—Three scholarships, established 1910, open for five years in any department of the University.

39. THE GEORGE W. FETTER SCHOLARSHIP, established in May, 1910, by Mrs. George W. Fetter, in memory of her husband, subject to all the rules of the University.

40. CLASS OF EIGHTY-SIX COLLEGE MEMORIAL SCHOLARSHIP FUND.—Founded 1912 by the Class of 1886, College, for the tuition of one student.

41. HENRY WILSON SPANGLER MEMORIAL SCHOLARSHIP IN ENGINEERING, founded February, 1914, by the graduates of the Towne Scientific School, provides for the tuition of one student, preference to be given to needy students in the following order: Mechanical, Electrical, Chemical and Civil Engineering; in any allied branch of Engineering.

42. THE EDGAR MARBURG MEMORIAL SCHOLARSHIP.—Founded by the American Society for Testing Materials in memory of the late Professor Marburg. For the tuition of a student in the Department of Civil Engineering.

PRIZES FOR 1920-21*

I. PRIZES FOUNDED BY ORGANIZATIONS

1. THE HENRY REED PRIZE, founded by the SOCIETY OF THE ALUMNI (College), for the best English Essay by a member of the Senior Class, College, Wharton or Towne Scientific Schools, entitles the successful competitor to one year's interest on six hundred dollars. Essays in competition for this prize are handed to the Dean of the College for transmission to a committee of the Board of Trustees, by whom the prize is awarded. A definite subject is announced for each year's competition.

2. A prize founded by the PHI KAPPA SIGMA FRATERNITY in honor of their founder, Samuel Brown Wylie Mitchell, M.D., of the Class of 1852, for the most meritorious work done in the course in English Composition of the second year. It entitles the successful competitor to one year's interest on four hundred dollars.

3. THE PRIESTLEY CLUB, composed of Alumni of the Chemical Department, offers a prize of twenty dollars each year to that member of the Graduating Class of that Department, whose work for that year is most satisfactory. The award of the prize is to be determined by the Director of the John Harrison Laboratory of Chemistry, based upon the student's application, the grade obtained by examination, and the presentation of a satisfactory thesis.

4. THE DANTE SOCIETY offers annually a prize of one hundred dollars for the best essay on a subject drawn from the life and works of Dante. Competition is open to all students, and graduates of not more than three years' standing, of any college or university in the United States. The judges of the essays submitted are a committee of the Society. For further information address the Secretary of the Society, Professor F. N. Robinson, Longfellow Park, Cambridge, Mass.

5. THE PHILADELPHIA GROUP OF THE ALLIANCE FRANÇAISE, established in 1904, awards annually a medal to the student of either the Junior or Senior classes who has done the most meritorious work in French over and above the required courses.

* All essays in competition for prizes must be handed to the appropriate Dean on or before May 1 in each year, must be signed with a fictitious name, and be accompanied by a sealed envelope, on which is written the fictitious name, and in which are enclosed the writer's real name and address. No prize will be awarded unless the work done for it reaches a high standard of excellence. Unless otherwise stated, the prizes are open to regular students only.

6. ORATORY PRIZE FUND, founded 1874 by the Society of the Alumni. A prize for the best and a prize for the second best original declamation by a member of the Junior Class; the first prize of \$25, and the second prize of \$15.

II. PRIZES FOUNDED BY INDIVIDUALS

1. A prize founded by HENRY LABARRE JAYNE, of the Class of 1879, for the best English Composition by a member of the Freshman Class. It entitles the successful competitor to one year's interest on two hundred dollars. A definite subject is announced for each year's competition.

2. A prize, originally founded by the late D. VAN NOSTRAND and generously continued by his business successors, for the member of the Junior Class in Civil Engineering who attains the highest general average of scholarship during the Junior year. The prize consists of twenty-five dollars.

3. THE FRAZIER PRIZE.—GEORGE H. FRAZIER, of the Class of 1887, offers annually a prize (founded 1897) of a standard work in literature, to be chosen by him, and of a value of one hundred dollars, to the student in the College, Towne Scientific or Wharton Schools of the University of Pennsylvania, who, being a member of the Football team, Baseball team, Track team, or of the Crew, shall attain the highest standing in scholarship.

4. THE PHILO S. BENNETT PRIZE, given through the generosity of the HONORABLE WILLIAM J. BRYAN. The interest on four hundred dollars is to be awarded annually for the best essay on *The Principles of Free Government*.

5. HUGO OTTO WOLF MEMORIAL PRIZE.—Founded 1912 by the gift of Otto C. Wolf, in memory of his son. To be awarded to any member of the Senior Class in each of the Engineering Courses—Mechanical, Electrical, Civil and Chemical Engineering—who, during the Senior year, by the thoroughness and originality of his work, meets with the greatest approval of the professors in charge.

6. A. ATWATER KENT PRIZE.—This prize entitles the winner to one year's interest on five thousand dollars. To be awarded at Commencement to that member of the Senior Class in the Department of Electrical Engineering who, during his Junior and Senior years, has, in the judgment of the Staff of the Electrical Engineering Department, shown the greatest progress in judgment and general grasp of the broad principles of Electrical Engineering, and development in personality, and who shows the greatest promise of success in this field.

The name of the winner each year is placed on a tablet in the Engineering Building.

COURSES IN THE TOWNE SCIENTIFIC SCHOOL

The Faculty of the Towne Scientific School conducts the following courses:

1. *The Course in Chemistry.*
 2. *The Course in Chemical Engineering.*
 3. *The Course in Civil Engineering.*
 4. *The Course in Electrical Engineering.*
 5. *The Course in Mechanical Engineering.*
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1. *The Course in Chemistry* leads to the degree of *Bachelor of Science in Chemistry* and requires four years for completion.

2. *The Course in Chemical Engineering* leads to the degree of *Bachelor of Science in Chemical Engineering* and requires four years for completion.

3. *The Course in Civil Engineering* leads to the degree of *Bachelor of Science in Civil Engineering* and requires four years for completion.

4. *The Course in Electrical Engineering* leads to the degree of *Bachelor of Science in Electrical Engineering* and requires four years for completion.

5. *The Course in Mechanical Engineering* leads to the degree of *Bachelor of Science in Mechanical Engineering* and requires four years for completion.

THE COMBINED COURSES IN THE COLLEGE AND THE TOWNE SCIENTIFIC SCHOOL

These Combined Courses are designed to meet the needs of such students as may desire to acquire a broad and general foundation prior to taking up work leading to the degree in the particular course they have selected in the Towne Scientific School. The Combined Courses normally extend throughout a period of six years.

The work in the College is designed to give the student greater maturity of thought and breadth of view, thus better fitting him in every way for the more specialized work to follow.

A student with the required preparation may in four years complete all of the requirements for the Bachelor's degree in the College and at the same time all of the required work of the first two years in any of the regular courses in the Towne Scientific School.

Such a student is then admitted to the Junior Class in the Towne Scientific School, thereby enabling him to complete his course in the latter in two additional years.

Exceptional students entering the College with advanced credit may possibly be able to complete Combined Courses in less than six years.

A student entering with the intention of taking one of these Combined Courses must so specify to the Dean of the College in order that he may be assigned to a special adviser.

Such a student shall normally register for the first four years in the College.

For further information consult the Dean of the Towne Scientific School.

THE TOWNE SCIENTIFIC SCHOOL

A regular scientific course leading to a degree has existed in the College since the year 1852. In 1872 this course was enlarged and organized as a Department of Science, which, in 1875, was in large part endowed under the provisions of the will of the late JOHN HENRY TOWNE, Esq., a trustee of the University. In honor of his memory the Department of Science was named *The Towne Scientific School*, which now comprehends the courses in Chemistry, in Chemical Engineering, in Civil Engineering, in Electrical Engineering, and in Mechanical Engineering.

ENGINEERING BUILDING

The departments of Civil, Electrical, Mechanical and Chemical Engineering of the Towne Scientific School occupy a separate building. It is 300 feet long and 160 feet deep, with a wing 50 feet wide and 40 feet deep at one end, the total working floor space being approximately 128,000 square feet. The construction is fire proof throughout.

The building contains the necessary accommodations for serving as headquarters for all the students in engineering, and a sufficient number of class rooms and drawing rooms for handling all the technical subjects of the departments. In addition it contains extensive laboratories fully equipped with the best modern apparatus for experi-

mental work, pertaining to Civil, Electrical and Mechanical Engineering, including the testing of steam and gas engines, boilers, electric and hydraulic motors, dynamos, transformers and electrical apparatus, pumps and fans, refrigerating machinery, the investigation of the physical properties of the materials of engineering, the study of the laws governing the flow and discharge of water through orifices, weirs and pipes, and facilities for calorimetric and geodetic work. The shops are fully equipped for practical instruction in wood and iron working, forge and foundry work.

THE COURSE IN CHEMISTRY

OFFICERS

JOSIAH H. PENNIMAN, Ph.D., LL.D., ACTING PROVOST.

VICE-PROVOST.

JOHN FRAZER, Ph.D., DEAN OF THE TOWNE SCIENTIFIC SCHOOL.

WALTER T. TAGGART, Ph.D., *Chemistry*; *Director of the Department of Chemistry and of the JOHN HARRISON Laboratory of Chemistry.*

OWEN L. SHINN, Ph.D., *Chemistry.*

THOMAS P. MCCUTCHEON, JR., Ph.D., *Chemistry.*

JOHN FRAZER, Ph.D., *Chemistry.*

HIRAM S. LUKENS, Ph.D., *Chemistry.*

DANIEL L. WALLACE, Ch.D., *Chemistry.*

JOHN H. MÜLLER, Ph.D., *Chemistry.*

HERBERT S. HARNED, Ph.D., *Chemistry.*

J. CECIL RHODES, B.S., M.S., *Chemistry.*

HORACE R. BLANK, B.S. in Ch., *Chemistry.*

HARRY SELTZ, B.S. in Ch.E., *Chemistry.*

EDWIN F. PIKE, B.S., M.S., *Chemistry.*

HARRY A. ALSENTZER, B.S. in Ch., *Chemistry.*

GEOFFREY M. JAMES, B.Chem., *Chemistry.*

EDWARD P. FENIMORE, B.S. in Ch.E., *Chemistry.*

WILLIAM K. CLAYTON, B.S. in Ch.E., *Chemistry.*

WALLACE N. McNABB, B.S., M.S., *Chemistry.*

A. KENNETH GRAHAM, B.S. in Ch.E., *Chemistry.*

RUSSEL D. STURGIS, B.S., M.S., *Chemistry.*

J. ERSKINE HAWKINS, A.B., *Chemistry,*

The course in Chemistry extends over a period of four years, and leads to the degree of Bachelor of Science in Chemistry. The tuition fee is three hundred dollars (\$300) a year.

For requirements for admission to this course, see bulletin of Office of Admissions.

The two units of Modern Foreign Language may be German, French, Spanish or Italian, but both units must be in the same language.

METHODS AND EQUIPMENT

The work of the first term of the first year consists in the execution of a somewhat extended series of experiments upon the metals and non-metals. The student omits only those of greater difficulty, and such as require a skilled manipulator for their performance. In addition, he attends lectures and recitations, and solves numerous problems based upon the various reactions that he conducts practically. The skill and familiarity with chemical methods acquired in this way will fully prepare him for the work of the second term, which is mainly analytical, as also is the first term of the Sophomore year, though considerable time is allotted to the preparation of a selected series of inorganic salts.

In quantitative analysis he is given every opportunity to familiarize himself with purely scientific methods in gravimetric, electrolytic and volumetric analysis; also with gas analysis, the use of the spectroscope, and the methods of technical analysis applied to the various branches of Chemistry. The instruction in Theoretical Chemistry is given by lectures; that in Applied Chemistry by lectures, supplemented by frequent visits to the chemical plants in Philadelphia and adjacent cities. The lectures and recitations in Organic Chemistry are conducted parallel with practical work in this subject. The aim is to have the student prepare typical compounds from the whole field of Organic Chemistry. The most recent methods of analysis peculiar to this field receive due attention.

THE JOHN HARRISON LABORATORY OF CHEMISTRY provides a complete modern equipment for the prosecution of chemical studies, both undergraduate and graduate.

FRESHMAN CLASS (Ch.₄)

Number	Subject	Number of hours per week		Description on page
		1st Term	2d Term	
Chem. 2	General Inorganic Chemistry	18	—	64
" 4	Qualitative Analysis	—	18	64
Eng. 1	English Composition	2	2	76
" 40	English Literature	—	2	76
Fr. 2	French Reading	2	2	77
" 3	French Grammar	1	1	77
Ger. 2	German Reading	2	2	79
" 3	German Grammar	only one required	2	79
	and Composition			
Span. 2	Intermediate Spanish	1	1	79
Math. 31	Algebra	3	3	88
" 32	Analytic Geometry, Calculus	4	—	79
M. E. 91	Mechanical Drawing	—	4	79
" " 92	Elements of Engineering	3	—	86
M. T. 1	Military Training	—	2	86
P. E. 1	Physical Education	3	3	86-87
		2	2	87

SOPHOMORE CLASS (Ch.₃)

Number	Subject	Number of hours per week		Description on page
		1st Term	2d Term	
Chem. 4	Qualitative Analysis	18	—	64
" 7	Quantitative Analysis	—	13	65
Eng. 3	English Composition	—	2	76
" 42	English Literature (Novelists)	2	—	76
Fr. 4	French Reading	2	2	77
" 5	French Grammar	1	1	78
" 8	Scientific French	2	2	78
Ger. 5	Schiller's Life and Works	2	—	79
" 6	German Historical Prose	—	2	79
" 7	German Composition and Conversation	only one required	1	79
" 10	Scientific German			
Span. 4	Advanced Spanish	2	2	79
" 5	Spanish Correspondence and Conversation	2	2	88
Min. 1	Mineralogy	1	1	88
Phys. 26	Physics	3	3	78
" 27	Physics	6	—	88
M. T. 2	Military Training	—	6	88
P. E. 2	Physical Education	3	3	86-87
		2	2	87

JUNIOR CLASS (Ch.₂)

Number	Subject	Number of hours per week		Description on page
		1st Term	2d Term	
Chem. 7	Quantitative Analysis.....	13	—	65
" 9	Organic Chemistry.....	2	2	65
" 25	Applied Chemistry.....	—	12	66
" 21	Physical Chemistry.....	4	4	66
Eng. 1	Choice of English Electives.....	2	2	76
Fr. 9	Scientific French Reading } only one	2	2	78
Ger. 11	Scientific German Reading } required {	2	2	79
Min. 3	Determinative Mineralogy.....	2	2	78
Phil. 5C	Philosophy of Nature.....	—	3	87
Phys. 28	Physics.....	3	3	88
M. T. 3	Military Training..... } only one	5	5	86-87
P. E. 3	Physical Education..... } required {	2	2	87

SENIOR CLASS (Ch.₁)

Chem. 10	Organic Chemistry.....	3	3	65
" 12	Practical Organic Chemistry.....	10	10	65
" 13	Applied Chemistry.....	2	2	65
" 14	Analysis of Foods.....	—	8	65
" 15	Theoretical Chemistry.....	1	1	65
" 16	Electro-Chemistry.....	1	1	66
" 19	Practical Electro-Chemistry.....	8	—	66
" 24	Seminar.....	1	1	66
B. L. 1	Business Law.....	1	1	64
Eng. 1	Choice of English Electives.....	2	2	76
Geol. 3	Geology.....	3	3	78
M. T. 4	Military Training..... } only one	5	5	86-87
P. E. 4	Physical Education..... } required {	2	2	87

THE COURSE IN CHEMICAL ENGINEERING

The Course in Chemical Engineering covers a period of four years, and leads to the degree of Bachelor of Science in Chemical Engineering. The tuition fee is three hundred dollars (\$300) a year. Graduates who continue in the practice of their profession may receive the technical degree of Chemical Engineer under the provisions stated on page 25.

The chemical studies introduced into this course will not only give the student a thorough acquaintance with the fundamental principles of chemical science, but will also afford him a complete drill in analysis, and in the preparation of inorganic and organic products. Instruction in technical analysis and applied chemistry is reserved until the last year. Frequent excursions are made to adjacent plants for the purpose of studying practical processes in operation, and examining in detail the mechanical appliances in use.

For requirements for admission to the course in Chemical Engineering see the Admission Bulletin.

FRESHMAN CLASS (Ch. E.₄)

Number	Subject	Number of hours per week		Description on page
		1st Term	2d Term	
Chem. 2	General Inorganic Chemistry.....	18	—	64
" 5	Qualitative Analysis.....	—	14	65
Eng. 2	English Composition.....	2	2	76
" 41	English Literature.....	—	2	76
Fr. 2	French Reading.....	2	2	77
" 3	French Grammar.....	1	1	77
Ger. 2	German Reading.....	—	3	79
" 4	German Scientific Reading.....	3	—	79
Span. 2	Intermediate Spanish.....	3	3	88
Math. 54*	Higher Trigonometry, Analytic Geometry.....	3	—	80
" 55*	College Algebra.....	2	—	80
" 56*	Analytic Geometry (continued).....	—	3	80
" 57*	Advanced Trigonometry.....	—	2	80
M. E. 1	Elementary Drawing.....	3	3	81
" " 3	Shop Work.....	6	—	81
" " 13	Shop Work.....	—	6	81
M. T. 1	Military Training.....	3	3	86-87
P. E. 1	Physical Education.....	2	2	87

SOPHOMORE CLASS (Ch. E.₃)

Chem. 5	Qualitative Analysis.....	14	—	65
" 8	Quantitative Analysis.....	—	10	65
Eng. 4	English Composition.....	—	1	76
" 42	English Literature.....	2	—	76
Fr. 6	Scientific French Read'g.....	2	2	78
" 7	Scientific French Gram'r.....	1	1	78
Ger. 8	Scientific German.....	3	—	79
" 9	Literary German.....	—	3	79
Span. 4	Advanced Spanish.....	2	2	88
" 5	Spanish Correspondence and Conversation.....	1	1	88
Math. 59	Differential Calculus.....	4	—	80
" 60	Integral Calculus.....	—	4	80
M. E. 11	Mechanical Drawing and Sketching..	3	3	81
" " 14	Elements of Engineering.....	2	—	81
" " 15	Kinematics.....	—	3	82
Phys. 16-17	Physics.....	10	—	87-88
" 18	Physics.....	—	5	88
" 20	Analytic Dynamics.....	—	5	88
M. T. 2	Military Training.....	3	3	86-87
P. E. 2	Physical Education.....	2	2	87

* Entering students who fail to pass the classifying examination MA must take Math. 53 the first term; those not passing MT must take Math. 52 the first term (see page 21).

JUNIOR CLASS (Ch. E.₂)

Number	Subject	Number of hours per week		Description on page
		1st Term	2d Term	
Chem. 8	Quantitative Analysis.....	10	—	65
" 9	Organic Chemistry.....	2	2	65
" 25	Applied Chemistry.....	—	10	66
" 21	Physical Chemistry.....	4	4	66
E. E. 31	Elements of Electrical Engineering...	3	—	74
" " 32	Electrical Laboratory.....	4	4	75
" " 33	Electrical Machinery.....	—	2	75
M. E. 22	Mechanics of Materials.....	4	—	82
" " 23	Hydraulics.....	2	—	82
" " 26	Mechanical Laboratory.....	3	3	82
" " 28	Thermodynamics.....	—	3	83
" " 71	Graphics.....	—	3	85
M. T. 3	Military Training.....	5	5	86-87
P. E. 3	Physical Education.....	2	2	

SENIOR CLASS (Ch. E.₁)

Number	Subject	Number of hours per week		Description on page
		1st Term	2d Term	
Chem. 10	Organic Chemistry.....	3	3	65
" 12	Practical Organic Chemistry.....	10	10	65
" 13	Applied Chemistry.....	2	2	65
" 14	Organic Technical Analysis.....	—	6	65
" 16	Electro-Chemistry.....	1	1	66
" 20	Practical Electro-Chemistry.....	6	—	66
" 24	Seminar.....	1	1	66
B. L. 1	Business Law.....	1	1	64
E. E. 41	Industrial Applications of Electricity.	2	—	75
" " 42	Electrical Laboratory.....	4	—	75
M. E. 41	Machine Design.....	—	4	83
" " 46	Power Plants.....	4	—	84
" " 82	Applied Thermodynamics.....	2	—	85
" " 84	Mechanical Laboratory.....	—	3	86
M. T. 4	Military Training.....	5	5	86-87
P. E. 4	Physical Education.....	2	2	

THE COURSE IN CIVIL ENGINEERING

OFFICERS

JOSIAH H. PENNIMAN, PH.D., LL.D., ACTING PROVOST.

_____, VICE-PROVOST.

JOHN FRAZER, PH.D., DEAN OF THE TOWNE SCIENTIFIC SCHOOL.

MILO S. KETCHUM, C.E., *Civil Engineering; Director of the Department of Civil Engineering.*

EDWARD L. INGRAM, C.E., *Civil Engineering.*

HERMAN C. BERRY, A.B., B.S. in C.E., *Civil Engineering.*

WILLIAM C. H. SLAGLE, C.E., Sc.D., *Civil Engineering.*

EDWARD T. GRANDLIENARD, C.E., *Civil Engineering.*

WILLIAM S. PARDOE, B.A.Sc., C.E., *Civil Engineering.*

CLARENCE L. ECKEL, C.E., *Civil Engineering.*

WILLIAM T. LEGGO, C.E., *Civil Engineering.*

WILLIAM H. BARTON, JR., C.E., *Civil Engineering.*

EMORY F. STOVER, B.S. in C.E., *Civil Engineering.*

ARTHUR J. BOASE, B.S. in C.E., *Civil Engineering.*

LOUIS H. DOANE, B.S. in C.E., *Civil Engineering.*

WILLIAM CLEVER, *Civil Engineering.*

The course in Civil Engineering extends over a period of four years, and leads to the degree of Bachelor of Science in Civil Engineering.

The tuition fee is three hundred dollars (\$300) a year. Graduates who continue in the practice of their profession may receive the technical degree of Civil Engineer under the provisions stated on page 25.

For requirements for admission to the course in Civil Engineering see Admission Bulletin.

A combined course, requiring six years, of broader scope than the four-year course, is offered in the College and the Civil Engineering Department. Information concerning this course appears on page 32.

METHODS AND EQUIPMENT

In addition to general studies, the first two years include courses in surveying, roads and mechanics, and lead up to courses in theoretical and applied mechanics, railroads, hydraulics, geodesy, reinforced concrete, materials of construction and stresses in structures in the Junior year, followed in the Senior year by water supply, sanitary engineering,

masonry construction, railroad economics, contracts and specifications, higher structures, and design courses in steel and reinforced concrete structures, and hydraulics and masonry design. Considerable attention is given to highway engineering. In addition to courses in roads and pavements and the tests of road building materials, courses are given on the design of highway bridges, retaining walls, bridge abutments and other structures used on highways.

In surveying, the aim is to develop and train students by means of surveying, rather than to turn out trained surveyors. The field work in surveying is done by the students working in squads, making it necessary for each man to become familiar with all the details of the instruments and of surveying operations. The locker system is used in assigning surveying instruments to students.

The equipment of surveying instruments includes two theodolites reading to single seconds by micrometer microscopes, two triangulation transits reading to twenty seconds, fifteen engineers' transits, three precise levels, seven dumpy levels, nine wye levels, seven water levels, three plane tables, three compasses, four sextants, and a large assortment of rods, tapes and minor instruments.

The instruction relating to Materials of Construction is supplemented by work in the Civil Engineering Testing Laboratories.

The largest machine in these laboratories has a capacity of 600,000 pounds. It is an Olsen vertical four-screw machine, of the universal type, capable of receiving a column twenty-four feet long, provided with beam extensions below the floor level twenty-one feet long designed for a load of 200,000 pounds on a span of twenty feet.

The remaining equipment consists of a 200,000-pound Olsen three-screw universal machine with beam extensions thirteen feet long, a 100,000-pound Olsen machine, two 30,000-pound Olsen machines, one 30,000-pound Falkenau-Sinclair machine, one 60,000-inch-pound torsion machine, an autographic pendulum torsion machine of the Thurston-Riehle type, a 10,000-pound transverse machine, a cold-bend machine capable of bending a steel bar one square inch in section, a 15,000-pound wire-testing machine adapted also for receiving compression specimens up to a length of three feet, and a Turner-Hatt impact machine of 1,650 foot-pounds capacity with appliances for tension, compression, and bending tests. With the exception of the transverse, the wire-testing, and the pendulum-torsion machines designed for hand-operation, all of these machines are driven by independent electric motors.

These laboratories are further equipped with a great variety of special apparatus, including two beam fiber extensometers; a Johnson and a Ewing extensometer, the latter reading to 0.00002 inch; an Olsen

compressometer reading to 0.0001 inch; two deflectometers; a complete set of strain gages reading to 0.0001 inch; a set of calibrating levers; standard weights; shearing apparatus for iron, steel and timber; besides a large assortment of micrometers, calipers, speed indicators and tools for the preparation and marking of specimens.

The Lesley Cement Laboratory is fully equipped for testing cement, sand, and plain and reinforced concrete. It contains four slate-top mixing tables each provided with a damp closet and scales.

The testing apparatus in this laboratory consists of an Olsen and a Riehlé machine of the lever type, a Fairbanks and a Falkenau-Sinclair machine of the shot type, and a 50,000-pound hand-power hydraulic machine for compression tests. It is further equipped with an Olsen mechanical briquette-molding machine, a two-cubic-foot power-driven concrete mixer, a six-inch stone crusher, a large separating screen, a Howard and Morse automatic sieve apparatus for cement and sand, a Bauschinger expansion apparatus, apparatus for accelerated tests, nine soapstone immersion tanks, cement bins, briquette racks, and a very complete outfit of smaller apparatus, including balances, specific gravity apparatus, sieves, burettes, briquette molds, etc.

Special provision is made for work in concrete, including molds for beams up to thirteen feet long and a concrete immersion tank of suitable capacity for receiving these beams, a beam crane for their convenient handling and transportation, a concrete block for molding compression specimens, and storage bins for stone, sand, etc.

The road materials laboratory contains complete equipment for tests of paving brick, crushed stone for road use, bituminous materials and road surfaces. This includes brick rattlers, abrasion apparatus, viscosimeters, penetrometers, melting-point apparatus, ovens, concrete mixer, two stone crushers, etc.

The materials testing laboratories are equipped with apparatus and reagents for routine chemical tests of cement, iron and steel. There is also a special electric oven with pyrometer for heat treatment of small specimens.

A large and well-equipped laboratory is provided for instruction and research in hydraulics. The most important features of the installation are as follows:

A concrete reservoir of 23,000 gallons capacity, which receives the discharge from all apparatus and from which the laboratory supply is drawn by two electrically-driven two-stage turbine pumps, each with a capacity of 450 gallons per minute against a head of 165 feet; a low-lift centrifugal pump with a capacity of 2,000 gallons per minute against a head of 40 feet; a three-inch double-suction centrifugal pump with a capacity of 300 gallons per minute against a head of 60 feet; a vertical

circular pressure tank, $5\frac{1}{2}$ feet in diameter and 37 feet high, provided with attachments for orifices and other apparatus; a twelve-inch standpipe 65 feet high with overflows to regulate the static head; circuits of ten-inch pipe, with numerous openings for the attachment of minor apparatus, connected with the standpipe and with the pressure tank; and two concrete weir tanks, each 34 feet long and 5 feet wide, which may be used also for measuring tanks. The latter may be converted into canals by opening the gates below the weir crests, for the purpose of investigating the flow over dams of various profiles. Two steel chutes are provided with valves operated by hydraulic cylinders to divert the flow alternately into two weighing tanks each of 16,000 pounds capacity, mounted on weighing cars, for weighing continuously the discharge from any part of the laboratory. The laboratory also contains a nine-inch reaction turbine, a twelve-inch impulse wheel, water meters of various types, numerous gauges and a great variety of minor apparatus.

A well-equipped machine shop is provided for making and repairing apparatus and for preparing test specimens. Considerable special apparatus adapted to the particular requirements of the different laboratories has been made in the shop, under the immediate supervision of the various professors. Some of this apparatus was especially designed for use in research work.

Tours of inspection to manufacturing plants and to engineering works, completed or in course of construction, are made from time to time during the year by the Junior and Senior classes, but only in so far as they have a direct bearing on the work of the class room.

During the summer vacation following the Junior year, each student is required to prepare a memoir descriptive of some engineering work or manufacturing plant, based on his direct personal inquiries and observation.

The department library contains an excellent collection of the most recent technical works, supplementing the very complete collection of bound volumes of engineering journals and of the transactions of engineering societies in the Fairman Rogers collection. The leading technical journals are kept on file.

BRIEF COURSE IN HIGHWAY ENGINEERING

A Brief Course in Highway Engineering was given from January 31 to February 11, 1921, by the Civil Engineering Department, in co-operation with the Bureau of Public Roads, Department of Agriculture, Washington, D. C., the Pennsylvania State Highway Department, the Delaware State Highway Department, the New Jersey State Highway Commission, the Maryland State Roads Commission, and

the Bureau of Surveys and Bureau of Highways of the City of Philadelphia. During the first two weeks of the Brief Course recitations and lectures were given in Road Engineering, Highway Structures, Materials of Construction and Surveying, and laboratory instruction was given in Cement Testing, Grading of Aggregates, Concrete Testing, Road Materials Testing, Bituminous Materials Testing, Brick Testing and Steel Testing.

A Highway Engineering Conference was held during the third week of the Course.

The Brief Course was planned to give engineers, who had had considerable experience in construction, training in the most recent and important methods used in highway engineering. The total number of men attending the Brief Course was sixty-seven.

Announcement for this course will be made in a separate bulletin.

FRESHMAN CLASS (C. E.₄)

Number	Subject	-Number of hours per week		Description on page
		1st Term	2d Term	
C. E. 1	Descriptive Geometry.....	3	—	66
" " 2	Descriptive Geometry.....	—	3	66
" " 3	Freehand Drawing and Lettering....	3	—	66
" " 4	Mechanical Drawing.....	3	—	66
" " 5	Mechanical Drawing.....	—	3	67
" " 10	Elementary Surveying.....	—	2	67
Chem. 1	General Inorganic Chemistry.....	8	—	64
" 3	Qualitative Analysis.....	—	8	64
Eng. 2	English Composition.....	2	2	76
" 41	English Literature.....	—	2	76
Fr. 2	French Reading.....	2	2	77
" 3	French Grammar.....	1	1	77
Ger. 2	German Reading.....	—	3	79
" 4	German Scientific Read'g.....	3	—	79
Span. 2	Intermediate Spanish.....	3	3	88
Math. 54*	Higher Trigonometry, Analytic Geometry.....	3	—	80
" 55*	College Algebra.....	2	—	80
" 56*	Analytic Geometry (continued).....	—	3	80
" 57*	Advanced Trigonometry.....	—	2	80
M. T. 1	Military Training.....	3	3	86-87
P. E. 1	Physical Education.....	2	2	87

* Entering students who fail to pass the classifying examination MA must take Math. 53 the first term; those not passing MT must take Math. 52 the first term (see page 21).

SOPHOMORE CLASS (C. E.₃)

C. E. 11	Plane Surveying.....	7	—	67
" " 12	Topographic Surveying.....	—	6	67
" " 14	Railroad Curves.....	—	1	67
" " 20	Technical Mechanics: Statics.....	—	2	68
" " 36	Roads and Pavements.....	2	—	69
Eng. 4	English Composition.....	—	1	76
" 42	English Literature.....	2	—	76
Fr. 6	Scientific French Read'g.....	2	2	78
" 7	Scientific French Gram'r.....	1	1	78
Ger. 8	Scientific German.....	3	—	79
" 9	Literary German.....	—	3	79
Span. 4	Advanced Spanish.....	2	2	88
" 5	Spanish Correspondence and Conversation....	1	1	88
Math. 59	Differential Calculus.....	4	—	80
" 60	Integral Calculus.....	—	4	80
Phys. 16-17	Physics.....	10	—	87-88
" 18	Physics.....	—	5	88
" 20	Analytic Dynamics.....	—	5	88
M. T. 2	Military Training.....	3	3	86-87
P. E. 2	Physical Education.....	2	2	87

JUNIOR CLASS (C. E.₂)

Number	Subject	Number of hours per week		Description on page
		1st Term	2d Term	
C. E. 13	Geodesy.....	4	—	67
" " 15	Railroad Construction.....	8	—	67
" " 16	Railroad Maintenance.....	—	2	67
" " 21	Technical Mechanics: Dynamics....	3	—	68
" " 22	Mechanics of Materials.....	3	—	68
" " 23	Materials of Construction.....	3	—	68
" " 24	Materials Testing.....	3	—	68
" " 25	Cement Testing.....	—	3*	68
" " 30	Hydraulics.....	—	3	69
" " 31	Hydraulic Testing.....	—	3*	69
" " 40	Reinforced Concrete.....	—	2	70
" " 43	Framed Structures.....	—	7	70
" " 44	Structural Details.....	3	—	70
" " 50	Highway Bridge Design.....	—	3	71
Bac. 1	Bacteriology.....	—	2	64
E. E. 51	Applied Electricity.....	—	2	75
" " 52	Electrical Laboratory.....	—	3	75
M. T. 3	Military Training.....	} only one {		86-87
P. E. 3	Physical Education.....			
		5	5	
		2	2	87

* For half of the term.

SENIOR CLASS* (C. E.₁)

C. E. 17	Railroad Economics.....	2	—	68
" " 26	Road Materials Testing.....	3†	—	69
" " 31	Hydraulic Testing.....	3†	—	69
" " 33	Water Supply.....	2	—	69
" " 34	Sanitary Engineering.....	2	—	69
" " 35	Hydraulic Works Design.....	—	6	69
" " 41	Reinforced Concrete Design.....	3	—	70
" " 42	Masonry Construction.....	3	—	70
" " 45	Structural Engineering.....	9	—	70
" " 46	Bridge Design.....	3	—	70
" " 47	Bridge Design.....	—	3	71
" " 48	Masonry Design.....	—	3	71
" " 49	Higher Structures.....	—	5	71
" " 51	Advanced Highway Bridge Design...	—	3	71
" " 55	C. E. Seminar.....	—	2	71
" " 56	Engineering Contracts and Specifications.....	—	3	71
M. E. 93	Power Plants.....	—	4	86
M. T. 4	Military Training.....	} only one {		86-87
P. E. 4	Physical Education.....			
		5	5	
		2	2	87

* A Summer Memoir is required for admission to full standing in the Senior Class.

† For half of the term.

THE COURSE IN ELECTRICAL ENGINEERING

OFFICERS

JOSIAH H. PENNIMAN, PH.D., LL.D., ACTING PROVOST.

_____, VICE-PROVOST.

JOHN FRAZER, PH.D., DEAN OF THE TOWNE SCIENTIFIC SCHOOL.

HAROLD PENDER, PH.D., *Electrical Engineering; Director of the Department of Electrical Engineering.*

C. E. CLEWELL, E.E., *Electrical Engineering.*

CHARLES D. FAWCETT, B.S. in E.E., *Electrical Engineering.*

RICHARD E. BROWN, M.M.E., *Electrical Engineering.*

WALTER J. SEELY, E.E., *Electrical Engineering.*

ROBERT T. ANDERSON, B.S. in E.E., *Electrical Engineering.*

DAVID S. KEISER, B.S. in E.E., *Electrical Engineering.*

CHARLES N. WEYL, B.S. in E.E., *Electrical Engineering.*

The course in Electrical Engineering covers a period of four years, and leads to the degree of Bachelor of Science in Electrical Engineering.

Graduates of this course who continue in the practice of their profession receive the technical degree of Electrical Engineer three years after the Bachelor's degree has been conferred, upon presentation of an acceptable thesis. (See page 25.)

New students are admitted to advanced standing, provided they have satisfactorily pursued similar courses elsewhere.

The tuition fee for the courses in Electrical Engineering is three hundred dollars (\$300) a year.

SCOPE OF COURSES

The instruction in the course in Electrical Engineering comprises lectures, recitations, laboratory practice, drafting, shop work and excursions. Throughout the course emphasis is laid upon the application of fundamental principles to engineering problems. In general, the schedules are so arranged that one-half of each day is devoted to the work of the class room and the other half to the more practical labors of the drawing room, the shop, and the laboratory.

The combination of lecture and recitation courses and practical work is designed to give the student such a fundamental knowledge of the apparatus and methods used in developing, transmitting and utilizing electric power, and in the allied branches of engineering, as will fit him to begin the pursuit of any one of the several branches of the Electrical Engineering profession.

The work of the first two years is the same in the Electrical Department as in the Mechanical Department, and consists largely of training in chemistry, physics, mathematics, and modern languages. During the Junior and Senior years the studies deal chiefly with the fundamentals of electrical engineering and their application in the design and performance of electrical apparatus, machinery and systems.

These subjects may be broadly classified under the heads of dynamo-electric machinery, distribution and transmission, electric railways, electric lighting, and industrial applications of electric power. In addition, instruction is given in the Senior and Junior years in those branches of mechanical engineering, heat engineering, hydraulic engineering and surveying which have a direct bearing on electrical engineering practice. Courses in business law and economics are also given.

EXCURSIONS

Throughout the four years, occasional visits are made to power plants and manufacturing establishments to enable the student to become familiar with the production and utilization of electric energy on a commercial scale.

During the Senior year at least one out-of-town excursion is made. Such an out-of-town trip is required of all Senior Students in Electrical Engineering. This required trip will take about one week, and the expense per student will probably range from \$75 to \$125, depending somewhat upon his personal expenditures.

EQUIPMENT

Instruction in technical subjects is given in the Engineering Building, which is exceptionally well equipped with the apparatus and facilities needed for instruction in Electrical Engineering.

A separate drawing room is assigned to each class, and a separate desk is assigned to each student as far as possible, no desk being occupied by more than two students. The drawing rooms are admirably lighted and are available for study purposes at all times during the day. All class rooms and drawing rooms are used jointly with the Department of Mechanical Engineering.

The electrical laboratories at present occupy three divisions of the Engineering Building. One is used for instruction in technical electrical measurements and in standardization work. Another is devoted to investigations of direct current generators, motors and railway equipment. The third division provides for work with alternating current machinery and for photometry.

LIBRARY

The Chemical, Civil, Electrical and Mechanical Engineering Departments share a common library in the Engineering Building. This departmental library is well supplied with books, technical journals, and transactions of the leading engineering societies.

For requirements for admission to the course in Electrical Engineering see Announcement of the Office of Admissions.

FRESHMAN CLASS (E. E.₄)

Number	Subject	Number of hours per week		Description on page
		1st Term	2d Term	
Chem. 1	General Inorganic Chemistry	8	—	64
" 3	Qualitative Analysis	—	8	64
Eng. 2	English Composition	2	2	76
" 41	English Literature	—	2	76
Fr. 2	French Reading	2	2	77
" 3	French Grammar	1	1	77
Ger. 2	German Reading	—	3	79
" 4	German Scientific Read'g	3	—	79
Span. 2	Intermediate Spanish	3	3	88
Math. 54*	Higher Trigonometry, Analytic Geometry	3	—	80
" 55*	College Algebra	2	—	80
" 56*	Analytic Geometry (continued)	—	3	80
" 57*	Advanced Trigonometry	—	2	80
M. E. 1	Mechanical Drawing	3	3	81
" " 2	Shop Work	6	3	81
" " 4	Descriptive Geometry	3	3	81
M. T. 1	Military Training	3	3	86-87
P. E. 1	Physical Education	2	2	87

* Entering students who fail to pass the classifying examination MA must take Math. 53 the first term; those not passing MT must take Math. 52 the first term (see page 21).

SOPHOMORE CLASS (E. E.₃)

Eng. 4	English Composition	—	1	76
" 42	English Literature	2	—	76
Fr. 6	Scientific French Read'g	2	2	78
" 7	Scientific French Gram'r	1	1	78
Ger. 8	Scientific German	3	—	79
" 9	Literary German	—	3	79
Span. 4	Advanced Spanish	2	2	88
" 5	Spanish Correspondence and Conversation	1	1	88
Math. 59	Differential Calculus	4	—	80
" 60	Integral Calculus	—	4	80
M. E. 11	Mechanical Drawing and Sketching	3	3	81
" " 12	Shop Work and Shop Visits	6	6	81
" " 14	Elements of Engineering	2	—	81
" " 15	Kinematics	—	3	82
Phys. 16-17	Physics	10	—	87-88
" 18	Physics	—	5	88
" 20	Analytic Dynamics	—	5	88
M. T. 2	Military Training	3	3	86-87
P. E. 2	Physical Education	2	2	87

JUNIOR CLASS (E. E.₂)

Number	Subject	Number of hours per week		Description on page
		1st Term	2d Term	
E. E. 1	Principles of Electrical Engineering ..	5	—	72
" " 2	Electrical Measurements	2	—	73
" " 3-5	Electrical Laboratory	6	6	73
" " 4	Alternating Currents	—	5	73
" " 11	Illumination	2	—	73
" " 12	Seminar	1	1	73
C. E. 61	Surveying	—	4	72
Math. 43	Differential Equations	3	—	79
M. E. 22	Mechanics of Materials	4	—	82
" " 23	Hydraulics	2	—	82
" " 72	Machine Design and Kinematic Design	—	4	85
" " 26	Mechanical Laboratory	3	3	82
" " 28	Thermodynamics	—	3	83
" " 71	Graphics	—	3	85
M. T. 3	Military Training	5	5	86-87
P. E. 3	Physical Education	2	2	

SENIOR CLASS (E. E.₁)

E. E. 8	Electrical Measurements	2	—	73
" " 12	Seminar	1	1	73
" " 13	Electric Power Plants	—	3	73
" " 14	Electric Railways	—	2	74
" " 15	Motor Applications	—	2	74
" " 16	Distribution and Transmission	3	—	74
" " 17	Alternating Current Machinery	5	5	74
" " 18	Electric Machinery Laboratory	7	6	74
B. L. 1	Business Law	2	—	64
Ec. of B. 1	Economics	—	2	72
M. E. 46	Power Plants	4	—	84
" " 81	Hydraulic Engineering	2	—	85
" " 82	Heat Engineering	2	—	85
" " 83	Mechanical Laboratory	—	6	85
M. T. 4	Military Training	5	5	86-87
P. E. 4	Physical Education	2	2	

THE COURSE IN MECHANICAL ENGINEERING

OFFICERS

JOSIAH H. PENNIMAN, PH.D., LL.D., ACTING PROVOST.

—————, VICE-PROVOST.

JOHN FRAZER, PH.D., DEAN OF THE TOWNE SCIENTIFIC SCHOOL.

ROBERT H. FERNALD, B.M.E., M.E., A.M., Ph.D., *Dynamical Engineering; Director of the Department of Mechanical Engineering.*

J. VERNE STANFORD, B.S., M.E., *Mechanical Engineering.*

GEORGE E. CROFOOT, B.S. in M.E., *Mechanical Engineering.*

FRANK D. CARVIN, B.S. in M.E., *Mechanical Engineering.*

ALOYSIUS F. ALLWEIN, B.S. in E.E., *Mechanical Engineering.*

CONRAD V. HAHN, B.S. in M.E., *Mechanical Engineering.*

KINGSLEY E. DE ROSAY, B.S. in Ch.E., *Mechanical Engineering.*

BENJAMIN W. TAYLOR, B.S. in M.E., *Mechanical Engineering.*

ERNEST H. DICKENSON, A.B., E.M., *Mechanical Engineering.*

WILLIAM H. KAVANAUGH, M.E., *Experimental Engineering.*

WILLIAM A. SLOAN, B.S. in M.E., *Experimental Engineering.*

WILLIAM C. WETHERILL, B.S. in M.E., *Experimental Engineering.*

ARTHUR S. CALLEN, El.Met., *Experimental Engineering.*

HAROLD E. WALTER, B.S., *Experimental Engineering.*

AUGUST ULMANN, JR., M.E., *Experimental Engineering.*

HORACE P. FRY, B.S. in E.E., *Mechanical Drawing.*

FRANK BINNS, B.S. in M.A., *Mechanical Drawing.*

LESLIE S. TARLETON, B.S. in M.E., *Mechanical Drawing.*

HAROLD E. SCHOFIELD, *Mechanical Drawing.*

ARCHIBALD L. DUNLAP, B.S. in M.E., *Mechanical Drawing.*

JACK E. STRINGER, *Mechanical Drawing.*

JOHN J. MORRIS, *Mechanical Constructive Practice.*

GEORGE W. H. FAWKES, *Wood-working.*

PERCIVAL R. HALL, *Iron-working.*

CHARLES W. BLOEMKER, *Forging.*

JOHN F. MURPHY, *Iron Founding.*

LEE N. GULICK, B.S. in M.E., *Mechanical Constructive Practice.*

LOUIS L. HEPBURN, B.S. in M.E., *Mechanical Constructive Practice.*

The course in Mechanical Engineering covers a period of four years, and leads to the degree of Bachelor of Science in Mechanical Engineering.

Graduates of this course who continue in the practice of their profession receive the degree of Mechanical Engineer three years after the Bachelor's degree has been conferred, upon presentation of an acceptable thesis. (See page 25.)

New students are admitted to advanced standing, provided they have pursued similar courses elsewhere.

The tuition fee for the course in Mechanical Engineering is three hundred dollars (\$300) a year.

A combined course, requiring six years, of broader scope than the four-year course, is offered in the College and the Mechanical Engineering Department. Information concerning this course appears on page 32.

SCOPE OF COURSE

The instruction in the course in Mechanical Engineering comprises lectures, recitations, laboratory practice, drafting, shop work and excursions. The time allotted is so arranged as to give the student a general acquaintance with the principles involved. In general, the schedules are so arranged that one-half of each day is devoted to the work of the class room and the other half to the more practical labors of the drawing room, the shop, and the laboratory.

The combination of lecture and recitation courses and practical work is designed to give the student such a fundamental knowledge of the apparatus and methods used in design and construction, and in developing, transmitting and utilizing power, that he will be able to take up after graduation any of the general divisions of Mechanical Engineering.

The work of the first two years consists largely of training in shop work, drawing, chemistry, physics, mathematics, and modern languages. During the Junior and Senior years the studies are almost purely technical in character and may be broadly classified under the heads of mechanics, thermodynamics, electrodynamics, design, power measurement and plant installation and equipment.

EXCURSIONS

Throughout the four years, occasional visits are made to the shops and manufacturing establishments of Philadelphia and vicinity to enable the student to become familiar with the progress of manufacturing, the arrangement of machinery and the mechanism of the machinery itself.

During the Senior year, at least one required out-of-town excursion is made. In the spring of 1921, the places visited included Pittsburgh, Cleveland, Akron, St. Louis, Keokuk, Chicago, Detroit and Niagara Falls.

The expense involved by such excursions ranges from \$100 to \$150 for each student, depending somewhat upon his personal expenditures.

EQUIPMENT

Instruction in technical subjects is given in the Engineering Building, which is exceptionally well equipped for theoretical and practical instruction in Mechanical Engineering.

A separate drawing room is assigned to each class, and a separate desk is assigned to each student as far as possible, no desk being occupied by more than two students. The rooms are admirably lighted and are available for study purposes at all times during the day.

The mechanical laboratory, located on the first floor, is divided into sections devoted to the investigation of problems in hydraulics, materials of construction, gas engineering, boiler testing, refrigeration, heating and ventilation, and steam engineering.

The shops consist of a forge shop, foundry, iron-working and pattern shops with complete equipment.

LIBRARY

The Chemical, Civil, Electrical and Mechanical Engineering Departments share a common library in the Engineering Building. This departmental library is well supplied with books, technical journals, and transactions of the leading engineering societies.

For requirements for entrance to the course in Mechanical Engineering see Announcement of the Office of Admission.

FRESHMAN CLASS (M. E.₄)

Number	Subject	Number of hours per week		Description on page
		1st Term	2d Term	
M. E. 1	Mechanical Drawing.....	3	3	81
" " 2	Shop Work.....	6	3	81
" " 4	Descriptive Geometry.....	3	3	81
Chem. 1	General Inorganic Chemistry.....	8	—	64
" 3	Qualitative Analysis.....	—	8	64
Eng. 2	English Composition.....	2	2	76
" 41	English Literature.....	—	2	76
Fr. 2	French Reading.....	2	2	77
" 3	French Grammar.....	1	1	77
Ger. 2	German Reading.....	—	3	79
" 4	Scientific German Read'g.....	3	—	79
Span. 2	Intermediate Spanish.....	3	3	88
Math. 54*	Higher Trigonometry, Analytic Geometry.....	3	—	80
" 55*	College Algebra.....	2	—	80
" 56*	Analytic Geometry (continued).....	—	3	80
" 57*	Advanced Trigonometry.....	—	2	80
M. T. 1	Military Training.....	3	3	86-87
P. E. 1	Physical Education.....	2	2	87

* Entering students who fail to pass the classifying examination MA must take Math. 53 the first term; those not passing MT must take Math. 52 the first term (see page 21).

SOPHOMORE CLASS (M. E.₃)

M. E. 11	Mechanical Drawing and Sketching..	3	3	81
" " 12	Shop Work and Shop Visits.....	6	6	81
" " 14	Elements of Engineering.....	2	—	81
" " 15	Kinematics.....	—	3	82
Eng. 4	English Composition.....	—	1	76
" 42	English Literature.....	2	—	76
Fr. 6	Scientific French Read'g.....	2	2	78
" 7	Scientific French Gram'r.....	1	1	78
Ger. 8	Scientific German.....	3	—	79
" 9	Literary German.....	—	3	79
Span. 4	Advanced Spanish.....	2	2	88
" 5	Spanish Correspondence and Conversation....	1	1	88
Math. 59	Differential Calculus.....	4	—	80
" 60	Integral Calculus.....	—	4	80
Phys. 16-17	Physics.....	10	—	87-88
" 18	Physics.....	—	5	88
" 20	Analytic Dynamics.....	—	5	80
M. T. 2	Military Training.....	3	3	86-87
P. E. 2	Physical Education.....	2	2	87

JUNIOR CLASS (M. E.)₂

Number	Subject	Number of hours per week		Description on page
		1st Term	2d Term	
M. E. 21	Kinematic Design Drawings.....	3	—	82
" " 22	Mechanics of Materials.....	4	—	82
" " 23	Hydraulics.....	2	—	82
" " 24	Seminar.....	1	1	82
" " 25	Machine Design and Kinematic Design	3	3	82
" " 26	Mechanical Laboratory.....	3	3	82
" " 27	Graphics.....	—	5	83
" " 28	Thermodynamics.....	—	3	83
C. E. 61	Surveying.....	—	4	72
E. E. 31	Elements of Electrical Engineering..	3	—	74
" " 32	Electrical Laboratory.....	4	4	75
" " 33	Electric Machinery.....	—	2	75
M. T. 3	Military Training.....	5	5	86-87
P. E. 3	Physical Education.....	2	2	

SENIOR CLASS (M. E.)₁

M. E. 41	Machine Design.....	4	—	83
" " 42	Hydrodynamics.....	2	—	83
" " 43	Heat Power Engineering.....	3	—	83
" " 44	Seminar.....	1	1	83
" " 45	Mechanical Laboratory.....	7	2	83
" " 46	Power Plants.....	4	—	84
" " 47	Thesis.....	—	9	84
" " 48	Inspection Trip.....	—	—	84
" " 51*	Steam Engine.....	3	—	85
" " 52	Steam Turbine.....	—	3	85
" " 53*	Steam Machinery Design.....	—	4	85
" " 54	Heating and Ventilation.....	—	3	85
" " 55*	Internal Combustion Engine.....	3	—	85
" " 56	Manufacture and Distribution of Gas	—	2	85
" " 57*	Gas Engineering Design.....	—	4	85
B. L. 1	Business Law.....	2	—	64
C. E. 66	Reinforced Concrete.....	—	3	72
Ec. of B. 1	Economics.....	—	2	72
E. E. 41	Industrial Applications of Electricity	2	—	75
" " 42	Electric Machinery Laboratory.....	4	—	75
M. T. 4	Military Training.....	5	5	86-87
P. E. 4	Physical Education.....	2	2	

* First Term: Student may elect M. E. 51 or M. E. 55. Second Term: Student may elect M. E. 53 or M. E. 57.

BACTERIOLOGY

BACTERIOLOGY 1. An introductory course especially adapted to the needs of students in the department of civil engineering. Brief explanatory lectures are given, followed by laboratory exercises and demonstrations on the nature of bacteria, especially their activities in the removal of waste. Text book, Marshall's *Microbiology*, 2nd edition. Second semester. Two hours. One unit. Professor ABBOTT, Assistant Professor BERGEY.

BUSINESS LAW

BUSINESS LAW 1. (T.S.S.) The law and principles of contracts, negotiable instruments, agency, partnerships, corporations, and the sale and transfer of real and personal property, and the discussion of forms and problems thereunder. One hour, both terms, or two hours, one term. Mr. LUKENS.

CHEMISTRY

CHEMISTRY 1. *General Inorganic Chemistry*.—Recitation, conversational lectures and laboratory work. Experiments illustrating the principles of Chemistry. Four hours lecture and recitation and four hours laboratory. First term. Three units. Professors MCCUTCHEON and FRAZER, Messrs. ALSENTZER, JAMES, McNABB and GRAHAM, Assistants.

CHEMISTRY 2. Same as 1. Given in greater detail. Intended for students pursuing chemistry as a major subject. Two hours lecture, four hours recitation and twelve hours laboratory. First term. Professors TAGGART, MCCUTCHEON and FRAZER, Mr. ALSENTZER and Mr. HAWKINS.

CHEMISTRY 3. *Analytical Chemistry*.—Qualitative Analysis. Laboratory practice with lectures and recitations. Prerequisite, Chemistry 1. Four hours lecture and recitation and four hours laboratory. Second term. Three units. Assistant Professor MÜLLER, Messrs. SELTZ, BLANK and STURGIS.

CHEMISTRY 4. This course is to 3 what 2 is to 1. For Chemists. Prerequisite, Chemistry 2. Three hours lecture and recitation and fifteen hours laboratory. Both terms. Assistant Professor MÜLLER, Messrs. SELTZ and BLANK.

CHEMISTRY 5. Similar to 4. For Chemical Engineers. Prerequisite, Chemistry 2. Three hours lecture and recitation. Eleven hours laboratory. Both terms. Assistant Professor MÜLLER, Messrs. SELTZ and BLANK.

CHEMISTRY 7. *Analytical Chemistry*.—Qualitative Analysis. Intended for students pursuing chemistry as a major subject. Prerequisite, Chemistry 4. One hour lecture and twelve hours laboratory. Both terms. Professor LUKENS, Assistant Professor WALLACE and Mr. CLAYTON.

CHEMISTRY 8. Same as 7. Intended for Chemical Engineering students. Prerequisite, Chemistry 5. One hour lecture and nine hours laboratory. Both terms. Professor LUKENS and Assistant Professor WALLACE.

CHEMISTRY 9. *Organic Chemistry* (Elementary Course).—Illustrated lecture course, preliminary to 10. It is intended to give the student a general knowledge of the carbon compounds. Special attention is paid to practical application. Must be preceded or accompanied by Chemistry 7 or 8. Two hours. Both terms. Mr. RHODES.

CHEMISTRY 10. *Organic Chemistry* (Advanced).—Must be preceded by 9. Three hours. Both terms. Professor TAGGART, Mr. PIKE.

CHEMISTRY 11. *Organic Chemistry* (Minor Course).—Lectures, recitations and laboratory work. Prerequisite, Chemistry 3. One hour recitation and eight hours laboratory. Second term. Three units. Professor TAGGART, Messrs. RHODES, FENIMORE and CLAYTON.

CHEMISTRY 12. *Practical Organic Chemistry*.—Preparation and study of a series of typical organic compounds, together with their qualitative and ultimate analysis. Must be accompanied by Chemistry 10. Ten hours. Both terms. Professor TAGGART, Messrs. RHODES, PIKE and FENIMORE.

CHEMISTRY 13. *Applied Chemistry*.—Lectures upon subjects pertaining both to Inorganic and Organic Chemistry, supplemented by regular excursions to chemical plants. Prerequisite, Chemistry 25. Two hours. Both terms. Professor SHINN.

CHEMISTRY 14. *Analysis of Foods and Technical Products*.—Analysis of milk, butter, bread, honey, coffee, chocolate, sugar (with the use of the polariscope), pepper, water, soaps, lubricating oils, paints, tanning materials, etc., etc. Lectures and recitations, with practical exercises. Prerequisites, Chemistry 6 and 9. Two hours lecture and six hours laboratory. Second term. Professor TAGGART, Mr. RHODES.

CHEMISTRY 15. *Theoretical Chemistry*.—Lectures and recitations. Prerequisites, Chemistry 6 and 9. One hour. Both terms. Professor LUKENS.

CHEMISTRY 16. *Electro-Chemistry*.—Lectures, setting forth the theoretical side of the subject, with applications of the electric current to analysis, and to the preparation of chemical products. Prerequisite, Chemistry 6. One hour. Both terms. Professor LUKENS.

CHEMISTRY 19. *Practical Electro-Chemistry*.—Laboratory for Chemists. Must be accompanied by Chemistry 16. Eight hours. First term. Professor LUKENS.

CHEMISTRY 20. *Practical Electro-Chemistry*.—Laboratory for Chemical Engineers. Must be accompanied by Chemistry 16. Six hours. First term. Professor LUKENS.

CHEMISTRY 21. *Physical Chemistry*.—Lectures, one hour a week dealing with relations between theories and facts, as well as with the properties, and phase and energy relations of matter. Laboratory, three hours a week, measurement of densities of gases and liquids, boiling points, freezing points, practice with spectrometer, polarimeter, refractometer and various physico-chemical apparatus. Prerequisite, Chemistry 7. One hour lecture and three hours laboratory. Both terms. Assistant Professor HARNED.

CHEMISTRY 24. *Seminar*.—Discussion of chemical literature. One hour. Both terms. Professor Taggart.

CHEMISTRY 25. *Industrial Chemistry*.—Lectures, recitations and laboratory work dealing with the principles underlying industrial processes. Prerequisite, Chemistry 7 or 8. Twelve hours. Three and one-half units. Second term. Professor SHINN.

CIVIL ENGINEERING

CIVIL ENGINEERING 1. *Descriptive Geometry*.—Elementary projections. Problems of the point, line and plane; single-curved, double-curved and warped surfaces. Intersections. Three hours recitation. First term. One and one-half units. Assistant Professor SLAGLE.

CIVIL ENGINEERING 2. *Descriptive Geometry*.—Shade and shadows; isometric drawing and perspective. Three hours in drawing room. Second term. Three-fourths unit. Prerequisite, Civil Engineering 1. Assistant Professor SLAGLE.

CIVIL ENGINEERING 3. *Freehand Drawing and Lettering*.—Lines and figures on plane surfaces; freehand construction of curves; projections of solids, single and in groups. Three hours in drawing room. First term. Three-fourths unit. Assistant Professor SLAGLE.

CIVIL ENGINEERING 4. *Mechanical Drawing*.—Use of drafting instruments; conventional work; tinting and graining. Three hours in drawing room. First term. Three-fourths unit. Assistant Professor SLAGLE.

CIVIL ENGINEERING 5. *Mechanical Drawing*.—Drawings and tracings based on sketches made from measurements of actual models. Three hours in drawing room. Second term. Three-fourths unit. Prerequisite, Civil Engineering 4. Assistant Professor SLAGLE.

CIVIL ENGINEERING 10. *Elementary Surveying*.—Methods of field work; instruction in keeping notes; elementary field problems with chain and tape, compass, water level, engineer's level and transit. Tests of precision and methods of computing, including the use of the slide rule. Two hours in field. Second term. One-half unit. Prerequisite, Credit in Trigonometry. Assistant Professor GRANDLIENARD.

CIVIL ENGINEERING 11. *Plane Surveying*.—Theory relating to the use and adjustments of the instruments; theory of topographic, hydrographic, mining and city surveying. Field practice in the adjustment and use of field and office instruments, including a special land survey; calculations and mapping. One hour recitation and six hours in field. First term. Two units. Prerequisite, Civil Engineering 10. Assistant Professor GRANDLIENARD.

CIVIL ENGINEERING 12. *Topographic Surveying*.—Surveys with transit and stadia and with the plane table; azimuth and latitude determinations. Topographic mapping. Field work of running in simple, compound and transition curves. Six hours in field and office. Second term. One and one-half units. Prerequisite, Civil Engineering 11. Assistant Professor GRANDLIENARD.

CIVIL ENGINEERING 13. *Geodesy*.—Instruments and field methods used in geodetic surveying. Method of least squares and adjustment of observations. Geodetic theory and computations. Four hours in field and recitation room. First term. One and one-half units. Prerequisite, Civil Engineering 12. Professor INGRAM.

CIVIL ENGINEERING 14. *Railroad Curves*.—Elementary study of railroad curves. One hour in recitation room. Second term. One-half unit. Prerequisite, Civil Engineering 11. Assistant Professor GRANDLIENARD.

CIVIL ENGINEERING 15. *Railroad Construction*.—Advanced study of railroad curves and details of alignment. Turnouts and switches. Earthwork measurements and computations. Details of track construction. Paper location of railroads. Cost estimates. Two hours in recitation room and six hours in field and office. First term. Two and one-half units. Prerequisite, Civil Engineering 14. Professor INGRAM, Assistant Professor GRANDLIENARD.

CIVIL ENGINEERING 16. *Railroad Maintenance*.—Maintenance of track and structures. Materials of track construction. Rolling stock.

Signaling. Organization. Yards and terminals. Two hours recitation. Second term. One unit. Prerequisite, Civil Engineering 15. Professor INGRAM.

CIVIL ENGINEERING 17. *Railroad Economics*.—General theory of the inception and completion of railroad projects. Probable volume of traffic and its probable growth. Effect of details of alignment on operating expenses and revenue. Two hours recitation. First term. One unit. Prerequisite, Civil Engineering 15. Professor INGRAM.

CIVIL ENGINEERING 20. *Technical Mechanics: Statics*.—The mechanics of engineering rather than of astronomy and physics is here considered. Particular attention is given to developing and fixing fundamental concepts of equilibrium as applied to engineering problems. Both algebraic and graphic methods of calculation of problems are considered. Two hours recitation. Second term. One unit. Prerequisite, taken with Mathematics 60. Assistant Professor ECKEL.

CIVIL ENGINEERING 21. *Technical Mechanics: Dynamics*.—A continuation of Civil Engineering 20. Three hours recitation. First term. One and one-half units. Prerequisite, Civil Engineering 20. Assistant Professor ECKEL, Mr. BOASE.

CIVIL ENGINEERING 22. *Mechanics of Materials*.—This course covers the elasticity of materials; stress and strain; working stresses; resistance of pipes and riveted joints; bending moment, resisting moment; shear; elastic curve of beams; internal stress; fatigue of metals, etc. Three hours recitation. First term. One and one-half units. Prerequisite, Civil Engineering 20, and to be taken with Civil Engineering 21. Professor KETCHUM, Assistant Professor ECKEL.

CIVIL ENGINEERING 23. *Materials of Construction*.—Manufacture and physical characteristics of engineering materials; steel, iron, cement, timber, plasters, alloys, etc. In connection with this course, attendance on four assigned inspection trips is required. Three hours recitation. First term. One and one-half units. Prerequisites, Physics 16 and 17, and Civil Engineering 20. Professor BERRY.

CIVIL ENGINEERING 24. *Materials Testing*.—Tests for determining properties of steel, wrought iron, cast iron, alloys, timber, brick, etc. Three hours in laboratory. First term. Three-fourths unit. To be taken with Civil Engineering 22 and 23. Professor BERRY.

CIVIL ENGINEERING 25. *Cement Testing*.—Tests of cement, sand, stone for use in concrete. Tests of concrete, and reinforced concrete beams, etc. Three hours in laboratory for one-half of second term. Three-eighths unit. Prerequisite, Civil Engineering 24. Professor BERRY.

CIVIL ENGINEERING 26. *Road Materials Testing*.—Tests for determining the physical properties of sand, stone, bitumens, etc., used in road construction. Tests of concrete, paving brick, bituminous concrete, etc., for road surfaces. Three hours in laboratory for one-half of first term. Three-eighths unit. Prerequisites, Civil Engineering 24 and 25. Professor BERRY.

CIVIL ENGINEERING 30. *Hydraulics*.—Hydrostatics, a study of the pressures and forces of the liquids at rest; hydrokinetics, the science of water in motion, *i. e.*, flow through orifices, nozzles, adjutages and pipes, over weirs and in rivers; hydrodynamics, which deals with the pressures and forces created by water in motion and the utilization and creation of these forces in the hydraulic turbine and the centrifugal pump. Three hours recitation. Second term. One and one-half units. Prerequisite, Civil Engineering 21. Professor PARDOE, Mr. STOVER.

CIVIL ENGINEERING 31. *Hydraulic Testing*.—Tests for determining the discharge of water through orifices and pipes and over weirs; and of the efficiency of different types of hydraulic motors. Three hours in laboratory for one-half of second term and one-half of first term. Three-fourths unit. Prerequisite, taken with Civil Engineering 30. Professor PARDOE.

CIVIL ENGINEERING 33. *Water Supply*.—Consumption by municipalities. Yields from various sources. Examination of water-supplies. Impounding reservoirs. Purification. Distribution. Two hours recitation. First term. One unit. Prerequisite, Civil Engineering 30. Professor PARDOE.

CIVIL ENGINEERING 34. *Sanitary Engineering*.—Necessity for sanitary sewerage, amounts of house and of storm sewage, design and construction of sewerage systems, flushing, ventilating, maintenances, disposal, and treatment. Two hours recitation. First term. One unit. Prerequisite, Civil Engineering 30. Professor PARDOE.

CIVIL ENGINEERING 35. *Hydraulic Works Design*.—Design of a waterworks system, design of a sewerage system and the economics of an hydraulic power plant. Six hours in drawing room. Second term. One and one-half units. Prerequisites, Civil Engineering 33 and 34. Professor PARDOE.

CIVIL ENGINEERING 36. *Roads and Pavements*.—Construction, maintenance and cost. Consideration of the relative merits of the various types. Two hours recitation. First term. One unit. Mr. BARTON.

CIVIL ENGINEERING 40. *Reinforced Concrete*.—Theory of reinforced concrete slabs, beams, columns. Two hours recitation. Second term. One unit. Prerequisite, Civil Engineering 22. Professor BERRY.

CIVIL ENGINEERING 41. *Reinforced Concrete Design*.—Design of reinforced concrete buildings, reinforced concrete girders, and other reinforced concrete structures. Three hours in drawing room. First term. Three-fourths unit. Prerequisites, Civil Engineering 40 and 43. Professor BERRY.

CIVIL ENGINEERING 42. *Masonry Construction*.—Masonry construction; explosives; foundations for bridges and buildings; deep foundations; caisson work; culverts; dams, etc. Three hours recitation. First term. One and one-half units. Prerequisites, Civil Engineering 40 and 43. Assistant Professor SLAGLE.

CIVIL ENGINEERING 43. *Framed Structures*.—This course covers the elements of statics by algebraic and graphic methods. Stresses are calculated in roof trusses, bridge trusses and other framed structures for different systems of loads by algebraic and also by graphic methods. Influence diagrams are discussed and the stresses in simple bridges due to moving loads are calculated. Two hours recitation and five hours in drawing room. Second term. Two and one-fourth units. Prerequisite, Civil Engineering 22. Professor KETCHUM, Assistant Professor ECKEL.

CIVIL ENGINEERING 44. *Structural Details*.—The design of timber trestles. The design of simple beams and columns. The detail drawings of steel beams, columns, roof trusses. Three hours in drawing room. First term. Three-fourths unit. Prerequisite, taken with Civil Engineering 22. Assistant Professor ECKEL.

CIVIL ENGINEERING 45. *Structural Engineering*.—The calculation of the stresses in bridges, and the framework of buildings and other engineering structures. Stresses are calculated in the portal, in the two-hinged arch, in continuous beams, and a careful study is made of influence diagrams preliminary to the course in Higher Structures, Civil Engineering 49. A study is made of steel mill buildings, mine structures, grain elevators, ore bins, office buildings and similar structures. Three hours recitation and six hours in drawing room. First term. Three units. Prerequisites, Civil Engineering 43 and 44. Professor KETCHUM, Assistant Professor ECKEL.

CIVIL ENGINEERING 46. *Bridge Design*.—The complete design, including calculations and detail drawings, of a railroad plate girder bridge, and a railroad truss bridge. Three hours in drawing room. First term. Three-fourths unit. Prerequisites, Civil Engineering 43 and 44. Professor KETCHUM, Assistant Professor ECKEL.

CIVIL ENGINEERING 47. *Bridge Design*.—A continuation of Civil Engineering 46. Three hours in drawing room. Second term. Three-fourths unit. Prerequisite, Civil Engineering 46. Professor KETCHUM, Assistant Professor ECKEL.

CIVIL ENGINEERING 48. *Masonry Design*.—The design of retaining walls and of high dams. Three hours in drawing room. Second term. Three-fourths unit. Prerequisites, Civil Engineering 42 and 45. Assistant Professor SLAGLE.

CIVIL ENGINEERING 49. *Higher Structures*.—This course includes the calculation of stresses in statically indeterminate structures and the calculation of secondary stresses in structures. A study is made of the design of cantilever, arch, and swing bridges. Two hours recitation and three hours in drawing room. Second term. One and three-fourths units. Prerequisite, Civil Engineering 45. Professor KETCHUM.

CIVIL ENGINEERING 50. *Highway Bridge Design*.—A study is made of highway bridges. The course includes the estimate of the weight and the cost of a steel truss highway bridge; and also the calculations and detail drawings for a steel truss highway bridge. Three hours in drawing room. Second term. Three-fourths unit. Prerequisites, Civil Engineering 22 and 44. Professor KETCHUM, Assistant Professor ECKEL.

CIVIL ENGINEERING 51. *Advanced Highway Bridge Design*.—A study of the design of highway bridges and culverts; the calculation of the stresses in the elastic arch, and the design of a reinforced concrete highway arch bridge. Three hours in drawing room. Second term. Three-fourths unit. Prerequisites, Civil Engineering 45 and 46. Professor KETCHUM, Assistant Professor ECKEL.

CIVIL ENGINEERING 55. *C. E. Seminar*.—Each student prepares and presents before the class a biography of a noted engineer, a review of a technical book, and a long paper describing an engineering project of importance. Two hours in lecture room. Second term. One-half unit. Prerequisite, Senior standing. Professor KETCHUM.

CIVIL ENGINEERING 56. *Engineering Contracts and Specifications*.—The law of engineering contracts and specifications. A study is also made of the economics of engineering construction and the details of engineering organization for construction and operation. Three hours recitation. Second term. One and one-half units. Prerequisite, Senior standing. Professor KETCHUM.

CIVIL ENGINEERING 57. *Technical Lectures*.—Lectures on technical subjects are given by the members of the Civil Engineering Staff every second week. Attendance is required of all Freshmen Civil Engineering students,

CIVIL ENGINEERING 61. *Surveying*.—For Mechanical and Electrical Engineering students. A brief course in surveying and in the theory and use of the level, transit and other instruments. The work covers problems in pacing, chaining, compass and transit surveys, profile and contour leveling, laying out buildings, etc. One hour in recitation room and three hours in field. Second term. One and one-fourth units. Prerequisite, Junior standing. Professor INGRAM, Mr. LEGGO.

CIVIL ENGINEERING 63. *Water Supply*.—Prescribed for students in the course in Public Hygiene. Consumption by municipalities. Yields from various sources. Examination of water-supplies. Impounding reservoirs. Purification. Distribution. Two hours recitation. Second term. One unit. Professor PARDOE.

CIVIL ENGINEERING 64. *Sanitary Engineering*.—Prescribed for students in the course in Public Hygiene. Necessity for sanitary sewerage, amounts of house and of storm sewage, design and construction of sewerage systems, flushing, ventilating, maintenance, disposal and treatment. One hour recitation. Second term. One-half unit. Professor PARDOE.

CIVIL ENGINEERING 65. *Materials Testing*.—Abridged course for students in Architecture taking the fourth-year option in construction. Tests for determining the properties of steel, wrought iron, cast iron and timber. Three hours in laboratory. First ten weeks of second term. One-half unit. Professor BERRY.

CIVIL ENGINEERING 66. *Reinforced Concrete*.—For Mechanical Engineering Seniors. Theory and design of slabs, beams and columns. Three hours recitation. Second term. One and one-half units. Assistant Professor SLAGLE.

CIVIL ENGINEERING 67. *Cement and Concrete Testing*.—Tests for determining the physical properties of cement, sand, mortar and plain and reinforced concrete. Three hours in laboratory. Second term. Three-fourths unit. Professor BERRY.

ECONOMICS

ECONOMICS OF BUSINESS 1. The principles of Economics adapted especially to the needs of engineering students. Given to Seniors in Electrical and Mechanical Engineering. Professor PATTERSON.

ELECTRICAL ENGINEERING

ELECTRICAL ENGINEERING 1. *Principles of Electrical Engineering*.—Principles of electricity and magnetism; electric and magnetic cir-

cuits; direct current generators and motors; storage batteries. Five hours. First term. Junior year. Two and one-half units. Prerequisites 18, 20 and concurrent with Electrical Engineering 3. Professor PENDER, Mr. KEISER.

ELECTRICAL ENGINEERING 2 and 8. *Electrical Measurements*.—The principles, construction, and use of instruments for the measurement of resistance, current, electromotive force, capacity, inductance, power and energy; methods of measuring these quantities; methods of calibrating commercial instruments; iron testing. Two hours. First term. Junior year. Two hours. First term. Senior year. One unit each. Prerequisites, concurrent with Electrical Engineering 1 and 4. Professor BROWN, Mr. SEELEY.

ELECTRICAL ENGINEERING 3 and 5. *Electric Laboratory*.—A laboratory course covering the same topics as Electrical Engineering 1, 2 and 4. Six hours. Both terms. Junior year. Three units. Prerequisites, concurrent with Electrical Engineering 1, 2 and 4. Mr. SEELEY and Instructors.

ELECTRICAL ENGINEERING 4. *Alternating Currents*.—Definitions of terms; instantaneous values and effective values; phase relations; power factor; impedance and reactance; calculations of circuits; analysis of complex waves; polyphase circuits; building up and decay of current and voltage in circuits. Five hours. Second term. Junior year. Two and one-half units. Prerequisites, Electrical Engineering 1, Mathematics 43, and concurrent with Electrical Engineering 3 and 5, Professor PENDER, Mr. KEISER.

ELECTRICAL ENGINEERING 11. *Illumination*.—Principles of illuminating engineering; photometry; practical problems in the lighting of factories and offices. Two hours. First term. Junior year. One unit. Prerequisites, concurrent with Electrical Engineering 1. Professor CLEWELL.

ELECTRICAL ENGINEERING 12. *Seminar*.—During the first term each Senior student is assigned one or more topics of timely interest. Upon each of these he prepares a paper of some 2500 words. He then presents extemporaneously a synopsis of this paper before the Senior class and Instructing Staff. During the second term, each Senior student reviews in an extempore talk of some twenty minutes, at least one important paper which has recently appeared in some one of the technical journals. One hour. Both terms. Senior year. (Juniors attend.) One unit. Prerequisites, Electrical Engineering 1 and 4. Professor PENDER and Staff.

ELECTRICAL ENGINEERING 13. *Electric Power Plants*.—Location of central station and substations; choice and arrangement of prime

movers and auxiliary apparatus for steam-electric and hydroelectric plants; plans and diagrams for typical layouts; preliminary cost estimates; operating and fixed charges. Three hours. Second term. Senior year. One and one-half units. Prerequisite, concurrent with Electrical Engineering 17. Professor FAWCETT.

ELECTRICAL ENGINEERING 14. *Electric Railways*.—Forces acting on a train; speed-time curves; energy requirements; motor capacity; train diagrams; distribution lines; power-house requirements; systems of control; alternating versus direct current; electricity versus steam; preliminary cost estimates. Two hours. Second term. Senior year. Prerequisite, concurrent with Electrical Engineering 17. Professor PENDER, Mr. SEELEY.

ELECTRICAL ENGINEERING 15. *Motor Applications*.—Analysis of the speed-torque characteristics of mechanical machinery to which electrical drive is applicable; selection of type of motor applicable thereto; types of motor control; costs. Two hours. Second term. Senior year. One unit. Prerequisite, concurrent with Electrical Engineering 17. Professor CLEWELL.

ELECTRICAL ENGINEERING 16. *Distribution and Transmission*.—Systems in use; general requirements; calculation of direct and alternating current lines; mechanical design; poles, towers, insulators, erection; control and protection; preliminary cost estimates. Three hours. First term. Senior year. One and one-half units. Prerequisites, Electrical Engineering 1 and 4. Professor PENDER, Mr. ANDERSON.

ELECTRICAL ENGINEERING 17. *Alternating Current Machinery*.—Principles involved in the design, construction, operation, and testing of alternators, synchronous motors, transformers, induction motors, and single-phase commutator motors. Five hours. Both terms. Senior year. Two and one-half units per term. Prerequisites, Electrical Engineering 1, 2, 3, 4 and 5, and concurrent with Electrical Engineering 18. Professor PENDER and Mr. BROWN.

ELECTRICAL ENGINEERING 18. *Electric Machinery Laboratory*.—Commercial methods of testing electric machinery and apparatus; special tests illustrative of the principles covered in Electrical Engineering 17; photometric and illumination tests. Seven hours. Both terms. Senior year. One and three-quarter units per term. Prerequisite, concurrent with electrical Engineering 11 and 17; Professor FAWCETT, Professor BROWN.

ELECTRICAL ENGINEERING 31. *Elements of Electrical Engineering*.—For students in Mechanical and Chemical Engineering. Fundamental principles of direct current and alternating current circuits and instru-

ments. A brief course covering the same topics as Electrical Engineering 1, 2 and 4. Three hours. First term. Junior year. One and one-half units. Prerequisites, Physics 18, 20, and concurrent with Electrical Engineering 32. Professor CLEWELL, Mr. SEELEY, Mr. ANDERSON, Mr. WEYL.

ELECTRICAL ENGINEERING 32. *Electric Laboratory*.—For students in Mechanical and Chemical Engineering. A laboratory course covering the same topics as Electrical Engineering 31 and 33. Four hours. Both terms. Junior year. Two units. Prerequisite, concurrent with Electrical Engineering 31 and 33. Professor CLEWELL and Instructors.

ELECTRICAL ENGINEERING 33. *Industrial Applications of Electricity*.—For students in Mechanical and Chemical Engineering. Covers approximately the same ground as Electrical Engineering 11 and 15. Two hours. Second term. Junior year. One unit. Prerequisites, Electrical Engineering 31, and concurrent with Electrical Engineering 32. Professor CLEWELL, Mr. SEELEY, Mr. ANDERSON, Mr. WEYL.

ELECTRICAL ENGINEERING 41. *Electric Machinery*.—For students in Mechanical and Chemical Engineering. The operating characteristics of alternating current machinery. A brief course covering the same topics as Electrical Engineering 17. Two hours. First term. Senior year. One unit. Prerequisite, Electrical Engineering 31, 32 and 33, and concurrent with Electrical Engineering 42. Professor FAWCETT and Instructors.

ELECTRICAL ENGINEERING 42. *Electric Machinery Laboratory*.—For students in Mechanical and Chemical Engineering. A laboratory course covering the same topics as Electrical Engineering 41. Four hours. First term. Senior year. One unit. Prerequisite, concurrent with Electrical Engineering 41. Professor FAWCETT and Instructors.

ELECTRICAL ENGINEERING 51. *Applied Electricity*.—For students in Civil Engineering. A short course dealing with the operating characteristics of generators and motors, with special reference to the application of the latter in civil engineering work. Two hours. Second term. Junior year. One unit. Prerequisites, Physics 18, 20, and concurrent with Electrical Engineering 52. Professor FAWCETT, Messrs. ANDERSON and WEYL.

ELECTRICAL ENGINEERING 52. *Electrical Laboratory*.—For students in Civil Engineering. A laboratory course covering the same topics as Electrical Engineering 51. Three hours. Second term. Junior year. Three-quarters of a unit. Prerequisite, concurrent with Electrical Engineering 51. Professor FAWCETT and Instructors.

ENGLISH

ENGLISH 1. *Composition*.—Weekly themes on assigned subjects. Prerequisites, English A and B (admission). Two hours. Both terms. Two units. Assistant Professors O'BOLGER, SHELLY, MCCLELLAND, OWEN, MENDENHALL, HARBESON, DOLMAN, LAURIE, BAUGH and KITCHEN, Messrs. BLACK, MUSSER, STINE, BRADLEY, JAMES, BOYD, CUNNINGHAM, BUTTERWORTH, HAVILAND, LONGAKER, HOSKINS, CLARK, BOLLES, LEACH, MCDANIEL, CHRIST, PHILLIPS, BROWN, RICHARDSON, SIBLEY, GRIFFIN, EDWARDS, WILLISTON and WALTON.

ENGLISH 2. The general method of English 1 is followed in this course, with special attention to the requirements of engineering students. Prerequisites, English A and B (admission). Two hours. Both terms. Two units. Instructors as for English 1.

ENGLISH 3. *Composition*.—Weekly themes; descriptive, narrative, expository. Prerequisite, English 1. Two hours. Second term. One unit. Instructors as for English 1.

ENGLISH 4. *Composition*. Weekly themes as in Course 3, except that the course extends over one term only. Prerequisite, English 2. One hour. One term. One-half unit. Instructors as for English 1.

ENGLISH 30. *English Language*.—An historical treatment of the English language. Prerequisites, English A and B (admission). Two hours. Second term. One unit. Professors CHILD and QUINN, Assistant Professors O'BOLGER, SHELLY, MENDENHALL and BAUGH, Messrs. BLACK, STINE and HAVILAND.

ENGLISH 40. *History of English Literature*.—From Anglo-Saxon times to the present day. Prerequisites, English A and B (admission). Two hours. Either term. One unit. Professors PENNIMAN, CHILD and WEYGANDT, Assistant Professors SHELLY, MCCLELLAND, OWEN, MENDENHALL, HARBESON, DOLMAN, LAURIE, BAUGH and KITCHEN, Messrs. BLACK, MUSSER and BRADLEY.

ENGLISH 41. *History of Modern English Literature*.—From Shakespeare to the present day. Prerequisites, English A and B (admission). Instructors as for English 40.

ENGLISH 41 F. *History of English Literature*.—For foreign students. A course specially designed to aid foreign students in making an acquaintance with English literature. Two hours. First term. One unit. Omitted in 1921-22. Assistant Professor O'BOLGER.

ENGLISH 42. *Nineteenth Century Novelists*.—Prerequisites, English 1, 30, 40. Two hours. First term. One unit. Professors PENNIMAN, QUINN and WEYGANDT, Assistant Professors MCCLELLAND, OWEN, MENDENHALL, HARBESON and KITCHEN, Messrs. MUSSER, STINE and BRADLEY.

ENGLISH 42 F. *Nineteenth Century Novelists*.—For foreign students. A course intended to acquaint foreign students with recent and contemporary English writers. Two hours. Second term. One unit. Omitted in 1920–21. Assistant Professor O'BOLGER.

ENGLISH 43. *English Essayists*.—Prerequisites, English 1, 30, 40. Two hours. Second term. One unit. Professors SCHELLING and PENNIMAN, Assistant Professor SHELLY.

ENGLISH 52. *Chaucer*.—Prerequisites, English 1, 30, 40. Two hours. Second term. One unit. Professor CHILD.

ENGLISH 61. *Readings in Shakespeare*.—Prerequisites, English 1, 30, 40. Two hours. Second term. One unit. Professor SCHELLING, Assistant Professor OWEN.

ENGLISH 62. *Elizabethan Dramatists*.—Prerequisites, English 1, 30, 40. Two hours. First term. One unit. Professor SCHELLING.

ENGLISH 89. *Representative American Authors*.—Prerequisites, English 1, 30, 40. Two hours. First term. One unit. Professor PENNIMAN.

ENGLISH 90. *Nineteenth Century Poets*.—Prerequisites, English 1, 30, 40. Two hours. First term. One unit. Professors SCHELLING and PENNIMAN, Assistant Professor McCLELLAND.

ENGLISH 91. *Nineteenth Century Drama*.—Prerequisites, English 1, 30, 40. Two hours. First term. One unit. Professor WEYGANDT.

ENGLISH 93. *English Literature in Ireland from 1850*.—Prerequisites, English 1, 30, 40. Two hours. Second term. One unit. Professor WEYGANDT.

For other electives in Composition, Journalism, Public Speaking, English and American Literature, see the announcement in the College Catalogue.

FRENCH

FRENCH 1. *Elementary*.—Elementary grammar and reading. Four hours. Both terms. Four units. Messrs. COLE, MALAKIS and JACK.

FRENCH 2. *Intermediate French Reading*.—Prerequisite, French 1 or admission A. Two hours. Both terms. Two units. Dr. YERONIMAKIS, Messrs. MEREDITH, WILLIAMS and DE LA FONTAINERIE.

FRENCH 3. *Intermediate French Grammar*.—Written and oral exercises. Prerequisite, admission A or French 1. One hour. Both terms. One unit. Same instructors as in French 2.

FRENCH 4. *Advanced French Reading*.—Prerequisite, French 2 or admission B. Two hours. Either term. Two units. Professors

BECK and HURLBURT, DR. VITTORINI, Messrs. COLE and DE LA FONTAINERIE.

FRENCH 5. *Advanced French Grammar*.—Prose composition and conversation. Prerequisite, French 3 or admission B. One hour. Both terms. One unit. Same instructors as in French 4.

FRENCH 6. *Scientific Reading*.—For Sophomore Engineers. Prerequisite, French 2. Two hours. Both terms. Two units. Mr. WILLIAMS.

FRENCH 7. *Scientific French Grammar*.—Prose composition and conversation. For Sophomore Engineers. Prerequisite, French 3. One hour. Both terms. One unit. Mr. WILLIAMS.

FRENCH 8. *Scientific Reading*.—For Sophomore Chemists. Prerequisites, French 2 and 3. Two hours. Both terms. Two units. Mr. WILLIAMS.

FRENCH 9. *Advanced Scientific French Reading*.—Reading of technical journals. For Junior Chemists. Prerequisite, French 4, or 6, or 8. Two hours. Both terms. Two units. Mr. WILLIAMS.

GEOLOGY, MINERALOGY

GEOLOGY 3. *General Geology*.—The fundamentals of the science of the earth. Igneous action, earthquakes and other dynamic agents and results. Lithology and structures, oceanic and physiographic geology. Outlines of Historical Geology, including the evidences of early human history. Three hours per week. Two terms. Three units. Assistant Professor EHRENFELD.

MINERALOGY 1. *Mineralogy*.—General introduction to the science of Mineralogy and Crystallography. An acquaintance with crystal forms and the chief groups of minerals is acquired by recitation and practice. Lectures are given on theoretical and practical aspects of minerals, together with a brief outline of the history of the science. Three hours. Both terms. Three units.

MINERALOGY 3. *Practical Determinative Mineralogy*.—Laboratory work in the practical study and determination of minerals by physical as well as chemical properties. Chemistry 1 and 3 should precede this course. Two hours. Both terms. One unit.

GERMAN

GERMAN 1. *Elementary German*.—Grammar and reading. Four hours. Both terms. Four units. Dr. FOGEL.

GERMAN 2. *Literary Prose*.—For Freshman Engineers. Prerequisite, German A (admission) or an approximate equivalent. Three hours. Second term. One and one-half units. DR. UPPVALL.

GERMAN 3. *Grammar and Composition*.—Written and oral exercises. Prerequisite, German A (admission) or an approximate equivalent. One hour. Both terms. One unit. DR. UPPVALL.

GERMAN 4. *Scientific Prose for Freshman Engineers*.—Prerequisite, German A (admission) or an approximate equivalent. Three hours. First term. One and one-half units. DR. UPPVALL.*

GERMAN 5. *Lectures on Schiller's Life and Works, and the Literary Movements of His Time*.—Reading of selected texts. Prerequisites, German 2 and 3. Two hours. First term. One unit. Assistant Professor DOERNENBURG.

GERMAN 6. *Reading of Selected Historical Prose*.—Prerequisites, German 2 and 3. Two hours. Second term. One unit. Assistant Professor DOERNENBURG.

GERMAN 7. *German Composition and Conversation*.—Prerequisite, German 3. One hour. Both terms. One unit. Assistant Professor DOERNENBURG.

GERMAN 8. *Intermediate Scientific German*.—Prerequisites, German 2 and 4. Three hours. Second term. One and one-half units. Assistant Professor DOERNENBURG.

GERMAN 9. *Literary German for Engineers*.—Prerequisites, German 2 and 4. Three hours. First term. One and one-half units. Assistant Professor DOERNENBURG.

GERMAN 10. *Scientific Reading for Chemists*.—Prerequisites, German 2 and 3. Two hours. Both terms. Two units. DR. WEIGAND.

GERMAN 11. *Advanced Scientific Reading*.—Prerequisite, German 10. Two hours. Both terms. Two units. DR. WEIGAND.

MATHEMATICS

MATHEMATICS 31. *Elementary Mathematical Analysis, Part I*.—For Freshmen in the course in Chemistry. Prerequisites, Mathematics A, C and F. Four hours. First term. Two units.

MATHEMATICS 32. *Elementary Mathematical Analysis, Part II*.—For Freshmen in the course in Chemistry. Prerequisites, Mathematics D, and 31. Four hours. Second term. Two units.

MATHEMATICS 43. *Differential Equations*.—For Juniors in the course in Electrical Engineering. Prerequisite, Mathematics 60. Three hours. First term. One and one-half units.

* Chemists take German 2 two hours a week for both terms in conjunction with German 3.

MATHEMATICS 51. *Solid Geometry*.—Prerequisites, Mathematics A or G, C. Two hours. First term. One unit.

MATHEMATICS 52. *Plane Trigonometry*.—For Freshmen in the Engineering courses who fail to pass the classifying examination Mathematics MT.* Prerequisites, Mathematics A or G, C. Three hours. First term. One and one-half units.

MATHEMATICS 53. *Intermediate Algebra*.—For Freshmen in the Engineering courses who fail to pass the classifying examination Mathematics MA.* Prerequisite, Mathematics G or A. Two hours. First term. One unit.

MATHEMATICS 54. *Higher Trigonometry, Beginning of Analytic Geometry*.—For Freshmen in the Engineering courses. Prerequisites, Mathematics A or G, C, F and MT,* or 52. Three hours. First or second term. One and one-half units.

MATHEMATICS 55. *College Algebra*.—For Freshmen in the Engineering courses. Prerequisites, Mathematics A and MA,* C; or 53, C. Two hours. First or second term. One unit.

MATHEMATICS 56. *Analytic Geometry, continued*.—For Freshmen in the Engineering courses. Prerequisites, Mathematics A or 53, D or 51, 54. Three hours. First or second term. One and one-half units.

MATHEMATICS 57. *Advanced Trigonometry*.—For Freshmen in the Engineering courses. Prerequisites, Mathematics A or 53, D or 51; must be preceded or accompanied by 54. Two hours. First or second term. One unit.

MATHEMATICS 59. *Calculus, Part I*.—For Sophomores in the Engineering courses. Prerequisite, Mathematics 55, 56; must be preceded or accompanied by 57. Four hours. First or second term. Two units.

MATHEMATICS 60. *Calculus, continued*.—For Sophomores in the Engineering courses. Prerequisites, Mathematics 59. Four hours. First or second term. Two units.

Those who receive credit for Mathematics A or F by ENTRANCE EXAMINATION in June or September immediately preceding admission to College, and those who bring proper credit from other colleges, are not required to take the corresponding parts of this classifying examination.

* The classifying examination, Mathematics M, is given in two parts, MA and MT, covering elementary algebra and elementary trigonometry respectively. This examination will be held in 1922 on Tuesday, September 26, at 10 A. M., in College Hall (see page 21).

MECHANICAL ENGINEERING

MECHANICAL ENGINEERING 1. *Mechanical Drawing*.—Use of instruments. Making detail mechanical drawings from working sketches. Freehand lettering. Three hours. Both terms. Freshman year. Professor FRY, Messrs. BINNS, TARLETON, SCHOFIELD and DUNLAP.

MECHANICAL ENGINEERING 2. *Shop Work*.—Elements of machines, wood working and forging. Collateral reading and monthly examinations. Six hours first term; three hours second term. Freshman year. Professor MORRIS, Messrs. FAWKES, HALL, MURPHY, BLOEMKER, GULICK, and HEPBURN.

MECHANICAL ENGINEERING 3. *Shop Work*.—Short course for Chemical Engineering students only. Six hours. First term. Freshman year. Professor MORRIS, Messrs. FAWKES, HALL, MURPHY, BLOEMKER, GULICK and HEPBURN.

MECHANICAL ENGINEERING 4. *Descriptive Geometry*.—Problems involving the essential relations of points, lines and planes; ruled surfaces and double-curved surfaces. Three hours. Both terms. Freshman year. Professor CROFOOT, Messrs. ALLWEIN, DE ROSAY, TAYLOR and DICKENSON.

MECHANICAL ENGINEERING 11. *Mechanical Drawing and Sketching*.—Continuation of Mechanical Engineering 1. Assembly and detail drawings made from sketches. Tracing. Checking. Blue printing. Machine sketching. Three hours. Both terms. Sophomore year. Prerequisites, Mechanical Engineering 1, 4. Professor FRY, Messrs. BINNS, TARLETON, SCHOFIELD and DUNLAP.

MECHANICAL ENGINEERING 12. *Advanced Shop Work*.—Pattern making. Use of machine tools. Principles of foundry practice. Laying out work. Six hours. Both terms. Sophomore year. Prerequisites, Mechanical Engineering 1, 2, 4. Professor MORRIS, Messrs. FAWKES, HALL, MURPHY, BLOEMKER, GULICK and HEPBURN.

MECHANICAL ENGINEERING 13. *Advanced Shop Work*.—Short course for Chemical Engineering students only. Six hours. Second term. Freshman year. Prerequisite, Mechanical Engineering 3. Professor MORRIS, Messrs. FAWKES, HALL, MURPHY, BLOEMKER, GULICK and HEPBURN.

MECHANICAL ENGINEERING 14. *Elements of Engineering*.—Nomenclature of steam machinery. General principles of the construction of machines. Power measurement. Two hours. First term. Sophomore year. Prerequisites, Mechanical Engineering 1, Mechanical Engineering 2 or 3. Professor CROFOOT, Messrs. CARVIN, ALLWEIN, HAHN, DE ROSAY and TAYLOR.

MECHANICAL ENGINEERING 15. *Kinematics*.—Laws of motion. Combination of pure mechanism. Pulleys and belts. Trains of gearing and forms of teeth of wheels. Link work, epicyclic trains, etc. Three hours. Second term. Sophomore year. Prerequisite, Mechanical Engineering 14. Professor CROFOOT, Messrs. CARVIN, ALLWEIN, HAHN, DE ROSAY and DICKENSON.

MECHANICAL ENGINEERING 21. *Kinematic Design Drawings*.—Designing and laying out mechanical movements. Practical designing of the parts of a mechanism. Three hours. First term. Junior year. Prerequisites, Mechanical Engineering 11, 12, 14, 15. Professor FRY, Messrs. BINNS and SCHOFIELD.

MECHANICAL ENGINEERING 22. *Mechanics of Materials*.—Application of the principles of statics to rigid bodies. Elasticity and strength of materials. Forms of uniform strength. Design of beams, columns and shafts. Combined and repeated stresses. Four hours. First term. Junior year. Prerequisites, Mathematics 60, Physics 16, 17, 20. Professor CROFOOT, Messrs. CARVIN, ALLWEIN, HAHN, DE ROSAY, TAYLOR and DICKENSON.

MECHANICAL ENGINEERING 23. *Hydraulics*.—Transmission of pressures. Determining centers and amount of pressure. Depth of flotation and stability. Flow through orifices, over weirs, through tubes, pipes and conduits. Water meters and the measurement of water power. Two hours. First term. Junior year. Prerequisites, Mathematics 60, Physics 16, 17, 20. Professor STANFORD, Messrs. CARVIN, ALLWEIN, DE ROSAY, TAYLOR and DICKENSON.

MECHANICAL ENGINEERING 24. *Seminar*.—The preparation of seminar papers and data sheets, a discussion of engineering articles in the current magazines, bulletins and proceedings, and a discussion of general engineering subjects. One hour. Both terms. Junior year. Prerequisite, in Junior year only. Professor FERNALD.

MECHANICAL ENGINEERING 25. *Machine Design and Drawing*.—Principles of machine design. Analytical design of machine elements. Elements of structural design, of trusses, girders, columns, and framing of buildings. Three hours. Both terms. Junior year. Prerequisites, Mechanical Engineering 11, 12, 14, 15, and concurrent with Mechanical Engineering 21, 22. Professor FRY, Messrs. TARLETON and DUNLAP.

MECHANICAL ENGINEERING 26. *Mechanical Laboratory*.—Testing mechanical apparatus. Adjusting scales, indicators, counters, gauges, etc. Determining the efficiency of various machines and the values of the materials of construction. Three hours. Both terms. Junior year. Prerequisites, Mechanical Engineering 11, 12 or 13, 15, Mathematics 60, and concurrent with Mechanical Engineering 22, 23. Pro-

fessor KAVANAUGH, Messrs. SLOAN, WETHERILL, CALLEN, WALTER and ULMAN.

MECHANICAL ENGINEERING 27. *Graphics.*—Principles of graphic statics and their application to cranes, bridges, roof trusses and other framed structures. The graphics of machinery with and without friction, graphic combination of stresses in shafts, etc. Five hours. Second term. Junior year. Prerequisites, Mechanical Engineering 11, 15, 22, Physics 16, 17, 20. Professor STANFORD, Messrs. CARVIN and ALLWEIN.

MECHANICAL ENGINEERING 28. *Thermodynamics.*—Mechanical theory of heat. Work done and heat expended in expansion. Cycles of perfect gases and vapors. Expansion of steam, ammonia and carbonic acid, work done and heat required. Mixtures of vapors. Three hours. Second term. Junior year. Prerequisites, Mechanical Engineering 14, Mathematics 60, Physics 16, 17, 20. Professors STANFORD and CROFOOT, Messrs. CARVIN, ALLWEIN, HAHN and DE ROSAY.

MECHANICAL ENGINEERING 41. *Machine Design.*—For students in Mechanical Engineering. Applications of the principles of machine design to special machinery. Four hours. First term. Senior year. Prerequisites, Mechanical Engineering 12, 15, 21, 22, 25, 27. Professor FRY, Messrs. TARLETON and DUNLAP.

MECHANICAL ENGINEERING 42. *Hydrodynamics.*—Theory of turbines, water wheels, and centrifugal pumping machinery. Two hours. First term. Senior year. Prerequisite, Mechanical Engineering 23. Professor STANFORD, Mr. CARVIN.

MECHANICAL ENGINEERING 43. *Heat Power Engineering.*—Heat engines, various efficiencies. Commercial results obtained and possibilities of development of steam, air, gas and oil engines. Refrigerating machines using air, ammonia, carbonic acid, etc. Flow of steam injectors and condensers. Three hours. First term. Senior year. Prerequisite, Mechanical Engineering 28. Professor STANFORD, Mr. HAHN.

MECHANICAL ENGINEERING 44. *Seminar.*—A continuation of Mechanical Engineering 24. One hour. Both terms. Senior year. Prerequisite, in last year only. Professor FERNALD.

MECHANICAL ENGINEERING 45. *Advanced Mechanical Laboratory.*—Testing steam, gas and air engines, and boilers, determining duty of pumps, injectors, air compressors, measurement of flow of steam, calorimetric work. Seven hours, first term; two hours, second term. Senior year. Prerequisites, Mechanical Engineering 22, 23, 26, 27, and concurrent with Mechanical Engineering 43. Professor KAVANAUGH, Messrs. SLOAN, WETHERILL, CALLEN, WALTER and ULMAN.

MECHANICAL ENGINEERING 46. *Power Plants*.—A discussion of the choice of types of prime movers for various installations, their relative cost, efficiency and durability. Many problems involved in the economic use of various kinds of fuel are presented. Four hours. First term. Senior year; Prerequisite, in last year only. Professor FERNALD, Messrs. WALTER and ULMAN.

MECHANICAL ENGINEERING 47. *Mechanical Thesis*.—Special work in Mechanical Laboratory. Nine hours. Second term. Senior year. Prerequisite, in last year only. Professor KAVANAUGH, Messrs. SLOAN WETHERILL, CALLEN, WALTER and ULMAN.

MECHANICAL ENGINEERING 48. *Out-of-Town Inspection Trip*.—An examination of the special features of important engineering developments in various sections of the country. Two weeks. Second term. Senior year. (Probable dates of 1922 trip, March 29 to April 12, inclusive.) Prerequisite, in last year only. Professor FERNALD.

MECHANICAL ENGINEERING 51. *Steam Engines*.—Systematic calculation of the proper proportions of the parts of a simple steam engine. Three hours. First term. Senior year. Prerequisites, Mechanical Engineering 22, 28. Professor STANFORD.

MECHANICAL ENGINEERING 52. *Steam Turbines*.—Theory of the steam turbine; advantages claimed for the different types; reported efficiencies and economies. Three hours. Second term. Senior year. Prerequisites, Mechanical Engineering 22, 28. Professor STANFORD, Mr. HAHN.

MECHANICAL ENGINEERING 53. *Steam Machinery Design*.—Determining the proper proportions of the parts of steam engines, boilers and turbines, calculating where a question of strength enters, and following commercial types for proportions that are determined solely from experience. Four hours. Second term. Senior year. Prerequisites, Mechanical Engineering 51, and concurrent with Mechanical Engineering 52. Professor STANFORD.

MECHANICAL ENGINEERING 54. *Heating and Ventilation*.—A discussion of the quantities of air required for proper ventilation; a study and layout of different systems of heating and ventilating, including heating from central stations. Three hours. Second term. Senior year. Prerequisite, Mechanical Engineering 28. Professor FERNALD, Mr. ULMAN.

MECHANICAL ENGINEERING 55. *Internal Combustion Engines*.—Theory and principles of operation. Construction features of various types, fuel mixtures, carburetion, systems of speed control, ignition, lubrication and cooling. Three hours. First term. Senior year.

Prerequisite, Mechanical Engineering 28. Professor KAVANAUGH, Mr. CALLEN.

MECHANICAL ENGINEERING 56. *Manufacture and Distribution of Gas*.—Principles involved in the manufacture of gases for power, light and heat. Apparatus for production and storage. Distribution systems. Two hours. Second term. Senior year. Prerequisite, in last year only. Professor KAVANAUGH, Mr. WETHERILL.

MECHANICAL ENGINEERING 57. *Gas Engineering Design*.—Determination of the principal dimensions of various types of internal combustion engines. Design of gas producer plants, city gas works, distribution systems and auxiliary apparatus. Four hours. Second term. Senior year. Prerequisites, Mechanical Engineering 22, 55, and concurrent with Mechanical Engineering 56. Professor KAVANAUGH, Mr. SLOAN.

MECHANICAL ENGINEERING 71. *Graphics*.—Same as Mechanical Engineering 27. For students in Electrical and Chemical Engineering. Three hours. Second term. Junior year. Prerequisites, Mechanical Engineering 11, 15, 22, Physics 16, 17, 20. Professor STANFORD, Messrs. CARVIN, ALLWEIN and TAYLOR.

MECHANICAL ENGINEERING 72. *Machine Design and Drawing*.—For students in Electrical Engineering. Principles of design applied to machine elements. Analysis of stresses and design of simple trusses and transmission towers. Four hours. Second term. Junior year. Prerequisites, Mechanical Engineering 11, 12, 14, 15, 22. Professor FRY, Mr. DUNLAP.

MECHANICAL ENGINEERING 81. *Hydraulic Engineering*.—Principles of hydraulic turbines; hydraulic power plants; hydrology. For students in Electrical Engineering. Two hours. First term. Senior year. Prerequisite, Mechanical Engineering 23. Professor STANFORD, Mr. CARVIN.

MECHANICAL ENGINEERING 82. *Heat Power Engineering*.—The fundamental principles of combustion, steam boilers, steam engines, steam turbines, gas engines and refrigeration. For students in Electrical and Chemical Engineering. Two hours. First term. Senior year. Prerequisite, Mechanical Engineering 28. Professor STANFORD, Mr. HAHN.

MECHANICAL ENGINEERING 83. *Advanced Mechanical Laboratory*.—Same as Mechanical Engineering 45. For students in Electrical Engineering. Six hours. Second term. Senior year. Prerequisites, Mechanical Engineering 22, 23, 26, 71, 82. Professor KAVANAUGH, Messrs. SLOAN, WETHERILL and CALLEN.

MECHANICAL ENGINEERING 84. *Advanced Mechanical Laboratory*.—Same as Mechanical Engineering 45. For students in Chemical Engineering. Three hours. Second term. Senior year. Prerequisites, Mechanical Engineering 22, 23, 26, 71, 82. Professor KAVANAUGH, Messrs. SLOAN, CALLEN and WALTER.

MECHANICAL ENGINEERING 85. *Chemical Plant Design*.—For students in Chemical Engineering. Laying out flow diagrams of processes. Selection of equipment and design of plant layout. Four hours. Second term. Senior year. Prerequisites, Mechanical Engineering 11, 13, 14, 15, 22 and 71. Professor FRY, Mr. TARLETON.

MECHANICAL ENGINEERING 91. *Mechanical Drawing*.—For students in Chemistry. Elementary drawing, freehand lettering and sketching. Two hours. First term. Freshman year. Professor FRY, Mr. SCHOFIELD.

MECHANICAL ENGINEERING 92. *Elements of Engineering*.—Same as Mechanical Engineering 14. For students in Chemistry. Two hours. Second term. Freshman year. Professor STANFORD, Mr. CARVIN.

MECHANICAL ENGINEERING 93. *Power Plants*.—For students in Civil Engineering. Four hours. Second term. Senior year. Prerequisites, Physics 16, 17. Professor FERNALD, Mr. WALTER.

MECHANICAL ENGINEERING 94. *Mechanical Drawing*.—Condensed course for Wharton School students in Industry. Principles of Orthographic Projection. Fundamentals and Terminology. Machine Sketching. Analysis and reading of industrial blue prints. Three hours. Second term. Sophomore year. Professor FRY, Messrs. TARLETON and DUNLAP.

MILITARY SCIENCE AND TACTICS

LIEUT. COLONEL SHELDON W. ANDING, Infantry, United States Army.

CAPTAIN JOHN HOPKINS, Infantry, United States Army.

CAPTAIN HAMILTON THORN, Infantry, United States Army.

CAPTAIN LLOYD S. SPOONER, Infantry, United States Army.

The Department of Military Science and Tactics was instituted under the Act of Congress of June 3, 1916. A four-year course, prescribed by the War Department, has been established, to qualify the students taking it for commissions as reserve officers. The course further aims to give all students in this Reserve Officers' Training Corps a thorough physical training, to implant in them a respect for all lawful authority and make them better citizens, to teach them the fundamentals of leadership, and to impart the special knowledge that will enable them to be efficient in all branches of the military service.

All students completing the prescribed work, including camp training, will receive a commission as second lieutenant, provided they are awarded degrees from the institution and are recommended by the Provost and the professor of Military Science and Tactics. Higher rank is open to the young officer who studies the military profession sufficiently to meet the requirements of the War Department.

PHILOSOPHY

PHILOSOPHY 5C. *Philosophy of Nature*.—Three hours. Second term. One and one-half units. Professor SINGER.

PHYSICAL EDUCATION

PHYSICAL EDUCATION 1 to 4. Medical and physical examination, swimming tactics, graded gymnastics, freehand and with apparatus, class athletics and gymnastic games, outdoor track and field athletics, remeasurement and examination. Lectures, Course C (second term only), for advanced students on history and physiology of physical training; anthropometry, gymnastic systems for school, playground, and college; application of exercise for defectives. Prerequisites: for Physical Education 2, Physical Education 1 or its equivalent as provided for in the Book of Regulations of the Department; for Physical Education 3, Physical Education 2 or its equivalent as provided for in the Regulations; for Physical Education 4, Physical Education 3 or its equivalent as provided for in the Regulations. Two hours. Both terms. One unit.

PHYSICS

NOTE: Courses 16 to 20 are primarily intended for students in Engineering, 26 to 28 for students in Chemistry.

PHYSICS 16. *Elementary Dynamics*.—This course assumes a knowledge of the usual elementary course in Physics as given in an average high school. It constitutes, when combined with Physics 17, 18 and 20, a complete course in General Physics designed for Engineering students. Prerequisites, Entrance Physics and Mathematics 54, 55, 56 and 57. Six hours lectures and recitations, four hours laboratory. First half of first term. Two units. Assistant Professor HARKINS and Staff.

PHYSICS 17. *Properties of Matter, Heat, Sound and Light*.—Prerequisite, Physics 16. Six hours lectures and recitations, four hours laboratory. Second half of first term. Assistant Professor HARKINS and Staff.

PHYSICS 18. *Electricity and Magnetism*.—Prerequisites, Physics 16 and 17; Mathematics 59. Three hours lectures and recitations, two hours laboratory. Second term. Two units. Professor BARKER and Staff.

PHYSICS 20. *Analytic Dynamics*.—A practical course in the elements of Dynamics, consisting largely of problems. Prerequisites, Physics 16 and Mathematics 59. Mathematics 60 must be taken concurrently. Three hours lectures and recitations, two hours laboratory. Second term. Two units. Professor RICHARDS and Staff.

PHYSICS 26. *General Physics*.—A course which in combination with course 27 forms a course in General Physics intended primarily for students in the four-year course in Chemistry. Prerequisites, Entrance Physics and Mathematics 32. Three hours lectures and recitations, three hours laboratory. First term. Two units. Professor GOOD-SPEED, Dr. LUCIAN.

PHYSICS 27. *General Physics*.—The continuation of Physics 26. Prerequisite, Physics 26. Three hours lectures and recitations, three hours laboratory. Second term. Two units. Dr. LUCIAN.

PHYSICS 28. *Theoretical Physics*.—A somewhat advanced course in theoretical physics during which a number of special topics are selected for detailed study. Prerequisite, Physics 27. Three hours. Both terms. Three units. Professor GOODSPEED.

SPANISH

SPANISH 1. *Elementary*.—Three hours. Both terms. Three units. Dr. VITTORINI, Messrs. MEREDITH, WILLIAMS, JACK and SENECA.

SPANISH 2. *Intermediate*.—Prerequisite, 1 or Spanish A (admission). Three hours. Both terms. Three units. Professors RENNERT and CRAWFORD, Messrs. MEREDITH and SENECA.

SPANISH 4. *Advanced Reading*.—Texts dealing with institutions and industries of Latin-America. Prerequisite, 2. Two hours. Both terms. Two units. Assistant Professor ROMERA-NAVARRO.

SPANISH 5. *Spanish Correspondence*.—Prerequisite, 2. One hour. Both terms. One unit. Assistant Professor ROMERA-NAVARRO.

DEPARTMENT OF PHYSICAL EDUCATION

At a meeting of the Board of Trustees, held in May, 1904, it was resolved that the course in Physical Education be made an integral part of the University curriculum. The following regulations are now in force:

The Gymnasium fee is collected from all students of the Towne Scientific School.

The Bursar's receipt entitles the holder to the use of the Gymnasium, shower-baths, swimming-pool and Franklin Field, and the River Fields, except when any or all of them are specially reserved, as, for example, in the case of intercollegiate games. Due notice of such reservation will be posted on the bulletin boards at the Gymnasium.

Every locker holder is entitled to a physical examination, including his measurements, a strength test, an examination of his heart, lungs, and general condition, with a special examination of his eyes. On the basis of this examination the kind and amount of exercise best adapted to his needs are outlined, and class instruction is given as arranged in the roster at the beginning of the college year.

In the following cases a certain minimum amount of gymnastic or athletic work is required, for which the student receives credit on the basis of laboratory work counting one unit a year toward his degree. In all other cases the work is optional.

Two periods a week are required in the Towne Scientific School, lasting one hour each, of all students, the work to be graded and made progressive throughout the four years.

Exceptional cases may be excused from this requirement when approved jointly by the Director of Physical Education and the Dean; and also the following cases:

First, all full students who have, in the opinion of the Director of the Department of Physical Education, had an equivalent amount of work at this, or another, university or college.

Second, holders of a *college degree*.

Excuse from the requirement, however, does not in any case waive liability for the payment of the gymnasium fee.

Credit in Physical Education may be obtained by attending the gymnastic classes; by membership on the athletic squads, attendance being reported weekly by the manager; by attending the classes in athletics and swimming; or in prescribed work. Details of all these being given in the Book of Regulations of the Department.

FACILITIES AND EQUIPMENT

I. The UNIVERSITY GYMNASIUM, presented to the Trustees by a committee of the Alumni.

The main exercise hall, 144 by 68 feet, is well lighted by a roof of glass, and has a specially designed system of ventilation, thus ensuring a constant supply of fresh air. The iron work overhead gives attachment to the heavy apparatus. The equipment is so arranged as to be quickly put in place or hoisted out of the way, leaving a clear floor space for large classes; while the floor can be divided into three equal spaces by nets, so as to permit the playing of games in which balls are used without interfering with other work. A small spectators' gallery occupies each end.

On the same floor are two rooms, one at each end, with 2450 expanded metal lockers, and boxes and accommodation for wrestling and corrective gymnastics, also two small dressing-rooms, with shower-baths, for the members of the Faculty and graduates. On the floor beneath are the towel-rooms and shower-baths. The floor below the exercise hall is occupied by the swimming-pool, the rowing-room, and two for boxing and fencing.

The pool, 100 by 30 feet, is supplied by a continuous stream of filtered water, which is completely changed once a week. It is commanded on three sides by a spectators' gallery. All the apparatus for teaching swimming is supplied, and the Instructor or his assistant is always in attendance.

The rowing-room, 75 by 30 feet, is used as an accessory gymnasium, with sixteen machines on which the crew do their winter training; and in it are found additional gymnastic apparatus. The two rooms, 30 by 30 feet each, at either end of the rowing-room, are fitted with all the appliances for teaching boxing and fencing.

The Director's office and examining rooms are situated in the north wing, while the corresponding rooms of the south wing contain the offices of the instructors and the superintendent of lockers and attendance.

The basement of each wing is taken up by the special Varsity dressing-rooms with lockers, baths, drying-rooms, repair shop and Instructors' rooms.

II. FRANKLIN FIELD, situated to the east of the gymnasium building and overlooked by it. It is encircled by quarter-mile cinder path and has permanent stands of brick on its north, east and south sides, capable of seating 20,000 spectators. Beneath them are the squash courts and an indoor running track. The stands are connected to the

north and south wings of the gymnasium building by brick arches, spanning the entrances to the field.

III. Three playing fields on the west bank of the Schuylkill, south of South Street Bridge.

Instruction is given in both the theory and practice of Physical Education, as follows:

A. Two demonstrations and lectures and demonstrations weekly for candidates for the Diploma of Public Health including Anthropometry, Laws of Growth, Physical Measurements and Examinations, Hygiene of School and College Life.

B. Two lectures a week to second year medical students on Physiotherapy including the application of Exercise, Massage, Hydro-therapy and Medical Electricity.

C. Twelve lectures in the Physiology of Exercise, Gymnastic Demonstrations, Teaching of Physical Education in Schools and Colleges and Playgrounds accompanied by demonstrations and practical tests to all undergraduates who have qualified by two years' experience as class leaders in Gymnastics and Athletics.

The successful passing of a theoretical and practical examination entitles the student to a special Certificate of Proficiency in the Theory and Practice of Physical Education.

The practical work of the department applies to the general student body. A careful medical examination, including a test of the sight and hearing, is made of all men coming under the regulations on entering college, and a series of measurements taken. On the basis of the information obtained at this examination the students are divided into three classes according to their physical condition. (a) Those who are below normal are given special work to remedy or correct such defects as scoliosis, flat-foot, weak chest, round shoulders, etc., which are susceptible to improvement by prescribed gymnastic exercise. (b) The average man for whom regular gymnastic and athletic courses are given, beginning with light freehand movements, and going forward by easy and progressive steps to the most advanced work on the whole range of gymnastic apparatus, track and field athletics. (c) Men who are representing the University on the river or the athletic field, or who are trying for any of the teams or crews.

All candidates for teams or crews must pass a satisfactory medical examination by the Director or medical examiner before being considered eligible to represent the University.

Proficiency in swimming is required of all the candidates for crews, and is taught to all students of the first year, who must pass the test at the end of the year to complete their credit in P.E. 1.

FINANCIAL OBLIGATIONS, DORMITORIES, ROOMS AND BOARD

REGULATIONS GOVERNING PAYMENTS

The following regulations governing the payment of fees, rents, charges, and deposits have been adopted by the Trustees of the University of Pennsylvania. The Trustees of the University of Pennsylvania reserve the right at any time to amend or add to the regulations of the University, including those concerning fees and method of payment, and to make such changes applicable to students at present in the University, as well as to new students.

CHANGE IN FEE REGULATIONS IN EFFECT

1921-1922

The attention of all students is directed to the following changes in regulations affecting registration and withdrawal. The change applies to all students, whether now in attendance or hereafter admitted.

(1) **LIABILITY OF MATRICULATES.**—A student, to whom a certificate of admission to any school of the University is issued, and who has filed a surety bond guaranteeing the payment of all obligations incurred by him, is in effect a matriculate. Therefore, if he proposes to sever his contractual relationship and not complete registration, he must give formal notice in writing to this effect to the Director of Admissions, for the Undergraduate Schools, or to the Dean of the respective Professional School, at least two weeks prior to the formal opening date of the school for the term next succeeding. For failure to give such notice the student is liable under the terms of his bond for the payment of fees in full for said term.

(2) **NOTICE OF WITHDRAWAL.**—If the student registers, and subsequently desires to sever his contractual relationship at the conclusion of said term, he is required to give formal notice in writing of intended withdrawal to the Dean of the School at least two weeks prior to the formal opening date of the school for the term next succeeding. For failure to give such notice the student is liable under the terms of his bond for the payment of fees in full for said term.

(3) **RETURN OF FEES ON ACCOUNT OF ILLNESS, ETC.**—A student who withdraws on account of illness or other physical disability, shall be given a return of an amount which shall be such proportionate part of the term fees as the number of weeks in which he is not in attendance bears to the number of weeks in the academic session, provided such proportionate part be not more than one-half of the term's fees. Formal notice of withdrawal, together with the doctor's certificate, must be filed with the Dean.

(4) **RETURN OF FEES—UNUSUAL CONDITIONS.**—A student who withdraws for causes other than physical disability, shall be entitled to no allowance upon the fees of the term. In case extraordinary conditions necessitate withdrawal, the student may make a formal statement in writing of these facts to the Bursar, and due consideration will be given to the equities of the case.

FAILURE TO PAY

If a student fails to pay his fees and other charges in accordance with the above regulations, his name is dropped from the University rolls and he is excluded from lectures, recitations, practical work and examinations until payment is made. The student will be held accountable for all absences incurred through the operation of this rule. If payment in full is not made within three weeks of the date upon which charges are due, the student may be permanently dropped from his class.

WITHDRAWALS, ALLOWANCES AND SPECIAL RULES

WITHDRAWAL.—*Separate written notice must in all cases be given to the Dean and the Bursar at the time of withdrawal.*

LEAVE OF ABSENCE.—The Dean of any faculty may, for good cause, grant a leave of absence to a student in good standing. No fee will be returned in such cases, but an allowance will be made upon the fees when the student re-enters the course, proportionate to the unexpired period of the session in which leave of absence was granted.

REPEATING A YEAR.—A student who does not complete the work for a degree or certificate within the time indicated for the course shall in any succeeding year or years pay tuition for all subjects then or previously repeated in class, provided that in no year shall the fee so paid exceed the regular fee for the course.

CREDIT FOR ADVANCE STANDING.—A student who enters any school or who is transferred from one school to another, with advance standing, will be given financial credit for all subjects in which advance standing is given, provided that, if the student takes more than the minimum

of work required for a degree or certificate, or repeats any subjects in class, the fee for the subjects so taken in excess or repeated shall be deducted before the allowance is made.

A student pursuing work in the Summer School of the University for which advance credit toward a degree or certificate is given in any other department of the University, will be given financial credit for all subjects in which advance credit is given.

LATE REGISTRATION AND ABENCE.—Neither late registration nor absence during the term shall entitle the student to a reduction in fees.

RIGHT TO WITHDRAW OR GRADUATE.—No one shall be granted a certificate of withdrawal or be graduated who has not paid in full all his financial obligations to the University.

TRANSCRIPTS OF RECORD.—A former student may receive one certified transcript of his scholastic record without charge. For every transcript after the first a charge of two dollars shall be made.

PAYMENTS—CASHING STUDENTS' DRAFTS

Payment due the University must be made in cash, or by cheque, bank draft, or postal money order, drawn to the order of the Trustees of the University of Pennsylvania for the exact amount due.

As an accommodation to students, the Bursar will cash at his office, 3433 Woodland Avenue, bank drafts on Philadelphia or New York, and postal money orders, for not more than \$150.

UNIVERSITY DORMITORIES, ROOMS AND TABLE BOARD

The University reserves the right to refuse permission to students to reside in any house not approved by the University Committee on Students' Residences. The Committee has voted not to approve houses offering accommodations to both sexes.

DORMITORIES.—All regular male matriculates are eligible to residence in the University Dormitories. List of vacant rooms, prices and other information will be furnished upon application to the Bursar of the University, 3433 Woodland Avenue, Philadelphia, Pennsylvania.

LISTS OF ROOMS.—The Committee prepares lists of approved lodging and boarding houses near the University, all of which have been personally inspected. These lists may be had from the Recorder, or from the Deans, or from the Bursar. The Committee desires to included in this list only those houses which offer sanitary and wholesome quarters at reasonable charges.

Before engaging quarters students should have a definite contract in writing, and are advised to request receipts for all payments.

TABLE BOARD.—Table board may be had in the vicinity of the University at prices from \$6.00 per week upwards.

BOARD AND LODGING—MINIMUM EXPENSE

The figures given herewith are based upon the cost of living, either in the Dormitories or in a boarding house:

Board and lodging, 37 weeks.....	\$350.00
Tuition and other fees.....	285.00
Text books, etc. (estimated).....	30.00
	<hr/>
	\$665.00

STUDENT EMPLOYMENT

An employment bureau which undertakes to serve self-supporting students is managed by the Christian Association of the University, at its office located on the third floor of Houston Hall. Each year between three hundred and four hundred men receive practical assistance in securing positions. A man's earnings, of course, largely depend upon the number of hours he can give to outside work, but the majority of applicants are able to secure at least their board and room or the equivalent.



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